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# tives for Technological Innovation in Air Pollution Reduction: An ETIP Policy Research Series

## Volume 9: INTERNAL OFFSETS AND TECHNOLOGICAL INNOVATION: SIX CASE STUDIES

April 1982

Prepared by:

ETIP

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# THE EXPERIMENTAL TECHNOLOGY INCENTIVES PROGRAM

The Experimental Technology Incentives Program (ETIP) of the National Bureau of Standards pursues an understanding of the relationships between government policies and technology-based economic growth. The pursuit of this objective is based on three premises:

- o Technological change is a significant contributor to social and economic development in the United States.
- o Federal, State, and local government policies can influence the rate and direction of technological change.
- o Current understanding of this influence and its impact on social and economic factors is incomplete.

ETIP seeks to improve public policy and the policy research process in order to facilitate technological change in the private sector. The program does not pursue technological change per se. Rather, its mission is to examine and experiment with government policies and practices in order to identify and assist in the removal of government-related barriers and to correct inherent market imperfections that impede the innovation process.

ETIP assists other government agencies in the design and conduct of policy experiments. Key agency decisionmakers are intimately involved in these experiments to ensure that the results are incorporated in the policymaking process. ETIP provides its agency partners with both analytical assistance and funding for the experiments while it oversees the evaluation function.

Because all government activities potentially can influence the rate and direction of technological change, ETIP works with a wide variety of agencies, including those that have regulatory, procurement, R&D, and subsidy responsibilities. Recent projects have included cooperative arrangements with the General Services Administration, Food and Drug Administration, Veterans Administration, Securities and Exchange Commission, Department of Energy, Environmental Protection Agency, Occupational Safety and Health Administration, and other Federal agencies as well as various State and local agencies.

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# INCENTIVES FOR TECHNOLOGICAL INNOVATION IN AIR POLLUTION REDUCTION: AN ETIP POLICY RESEARCH SERIES

## Volume 9: INTERNAL OFFSETS AND TECHNOLOGICAL INNOVATION: SIX CASE STUDIES

Mary Ellen Mogee

April 1982

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Experimental Technology Incentives Program
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Washington, DC 20234

ETIP

This research series has been conducted by the Experimental Technology Incentives Program, National Bureau of Standards, Department of Commerce (Daniel W. Fulmer, Regulatory Policy Group Leader). Volumes in the series include:

Vol. 1 Emission Offset Policy at Work; A Summary Analysis of Eight Cases
by William H. Foskett (April 1979)

Vol. 2 Market Mechanisms for Emission Regulation and Enforcement of Emission Limits: Deterrence and Demand
by William H. Foskett (June 1979)

Vol. 3 Opportunities for Innovation: Administration of Sections 111(j) and 113(d)(4) of the Clean Air Act and Industry's Development of Innovative Control Technology
by Jay Evans (January 22, 1980)

Vol. 4 Analysis of the Rationale and Public Comment Regarding EPA's Proposed Regulation on Regional Consistency
by Jay Evans and William H. Foskett (December 1979)

Vol. 5 An Annotated Bibliography of Literature on Market Mechanisms and Economic Incentives for Environmental Regulation
by Steve Watson (October 1979)

Vol. 6 Innovation by Regulation: The Administration of Control Technology Requirements Under the Clean Air Act
by William Foskett, Adrienne Jamieson, and Jay Evans (March 1981)

Vol. 7 Periodic Review and Technological Escalation of Performance Standards: New Source Performance Standards Review Process
by William Foskett and Terry Olesen (December 1980)

Vol. 8 Controlled Trading and Site Specific SIP Revisions: Competing for Attention in a Crowded Administrative Route
by Jay Evans (December 1980)

Vol. 9 Internal Offsets and Technological Innovation: Six Case Studies
by Mary Ellen Mogee (April 1982)

## Overview

The volumes that make up this policy research series are all by-products of a long-term project of the Experimental Technology Incentives Program (ETIP) aimed at developing and evaluating an administrative experiment in regulatory incentives for air pollution reduction. As with other ETIP projects, the focus is on trying out new ideas for government process and policy hypothesized to have a beneficial impact on the rate and direction of technological innovation. In the area of environmental regulation economists and other expert commentators (see Volume 5 of this series, An Annotated Bibliography of Literature on Market Mechanisms and Economic Incentives for Environmental Regulation) have contended for some time that the conventional approach of regulatory standards may have reached its limit in reducing environmental pollution and that the technological innovation thought necessary to achieve the desired levels of air and water quality may only come about through new incentive approaches. The hypothesis is that the economic forces of the marketplace, i.e., buying and selling, profit maximization, cost reduction and entrepreneurial risk taking, can be utilized in such a way that private firms will perceive incentives to develop new innovative technology.

This policy research series provides background information and analysis regarding the factors considered essential for transforming the theory of economic incentives into reality. An administrative experiment is advanced on the notion that initial trials of new ideas can help to test them prior to full scale introduction. Such administrative trials serve to confirm theories or modify them. The methodology of regulatory administrative experimentation is a developing one since the principles of classical laboratory experimentation are hardly suited to the dynamics of political agency change and decisionmaking. Experimentation is used in the sense of a systematic process of change and evaluation of its impacts, adhering to certain standards of credibility. More discussion of this methodology can be found in the Regulatory Administrative Experiment Manual (NBS-GCR-ETIP 79-64), June 1979. Initial

findings and the status of individual experiments are reported in The Regulatory Processes and Effects Project (NBS-GCR-ETIP 79-65), June 1979.

The involvement of ETIP in the subject of incentives for environmental quality innovation began almost at the outset of the ETIP program in 1973. A series of studies by the Public Interest Economic Center was commissioned to explore possible ways in which changes in regulatory policy, practices and procedures might impact on the decisions of firms to innovate. The studies concerned themselves with ideas such as joint R&D pooling, compliance delays, innovation permits, effluent taxes and tax subsidies. These studies were completed in 1976. They are summarized, together with a synthesis and overview, in An Exploration of Regulatory Incentives for Innovation: Six Case Studies (NBS-GCR-ETIP 79-66), August 1979. In addition, ETIP developed, again with assistance from the Public Interest Economics Center, a Taxonomy of Incentives Approaches for Stimulating Innovation (NBS-GCR-ETIP 78-53), August 1978.

A progress report of such work was completed in 1979 and issued as a report: Balancing the Objectives of Clean Air and Economic Growth: Regulated Markets in Emissions Reductions, by William H. Foskett, David M. Klaus and John Haberle (NBS-GCR-ETIP 79-62), June 1979. As was said in that report:

> Our assessment that an evaluation has good prospects of success hinges on both resolution of evaluation problems presented and on strong indications that the resulting information would actually be used by decisionmakers.... Stakeholders' responses to the prospect of evaluation of EPA market mechanisms represented by this work will play an important role in our assessment of the usefulness of evaluating them.

This comment is still true as of this writing.

By 1979 EPA already had underway an example of economic incentive approaches, namely the EPA Emission Offset Interpretative Ruling of December 21, 1976. In a two year span of time, EPA granted a small number of construction permits to new source owners who could demonstrate that another polluter would make emission reductions greater than the

amount of emissions which would come from the new plant. In other words, private firms traded in pollution reduction capabilities.

The next step in the experimentation process was to trace what actually occurred in a number of these trading cases. The purpose of these trace cases was to provide information on the offset policy and also to explore further the viability of other suggested market mechanisms as candidates for experimentation and evaluation.

These trace cases were undertaken by William Foskett of the Performance Development Institute. A key question to be answered was: will a market in emission reductions develop? The trace cases provided information on the trends emerging in the market from the initial offset rulings. The cases are reported in Volume 1 of this current series: Emissions Offset Policy at Work: A Summary Analysis of Eight Cases by William H. Foskett. The report indicated the following trends: (1) external offsets were rare, i.e., permit applications entailing emission reductions made by a source not owned by the permit seeker; instead more typical were offsets made internally by the same firm; (2) as a consequence, there was little private trading going on; (3) middlemen played a catalytic role in external offset cases examined, e.g., Chambers of Commerce, state development offices, etc., in some cases tending to preempt the occasion for real trading.

Another aspect of creating a real market is the formation of demand. Individual sources' needs for emission reductions are the origin of demand that is an essential, central component of any market. Unless sources need reductions, there will be no motive to buy emission reductions. One way to create demand is strong and consistent enforcement of emission limits. The problems of ensuring such enforcement are discussed in the second volume in this series: Market Mechanisms for Emission Regulation and Enforcement of Emission Limits: Deterrence and Demand, William H. Foskett, June 1979. As with most enforcement processes, much depends on perception. As the report states: "The eventual effectiveness of sanctions hinges on the perceived probability of first getting

caught in violation." Deficits in the detection stage of enforcement are examined in this report. Beyond detection, however, there is the question of whether even once caught, pollution might pay. The report discusses current steps being taken by EPA to ensure that the prospect of penalties will act as economic incentive for speeding compliance. Even here, given the complexity of ensuring such a prospect, it is possible a further positive incentive is needed that might enhance profit for compliance. The report calls out the possibility for such an incentive existing in the authority for granting innovation permits.

The subject of innovation waivers or permits is more thoroughly explored in the third volume of the series: Incentives for Innovation: How Sections 111(j) and 113(d)(4) of the Clean Air Act Affect Industry's Development of Innovation Control Technology, Jay Evans, November 1979. The finding of this report is that the administration of the waiver authority has very modestly encouraged the industrial sector to develop innovative air pollution control technology, although the potential for greater utilization seems to exist untapped.

Another factor that might undercut the demand component of an emission reduction trading market is the problem of so-called "pollution havens." Such "havens" seem to stem from weak enforcement or inconsistent administration of the Clean Air Act. Regional consistency appears to be a necessary condition for the operation of the market mechanism approaches under consideration by EPA. In the Clean Air Act Amendments of 1977 the Congress authorized EPA to write regulations for creating regional consistency in administration and enforcement. Volume 4 of this series examines the rulemaking actions associated with this aspect: Analysis of the Rationale and Public Comment Regarding EPA's Proposed Regulation on Regional Consistency, Jay Evans and William H. Foskett, December 1979.

Volumes 6, 7, and 8 of the series are focused on the impacts upon innovation of the control technology and other administrative requirements of the current Clean Air legislation and EPA regulatory scheme. Since market mechanisms and economic incentives being tried by EPA are

carried out within the existing regulatory framework and requirements, it is important to look at the effects on innovation of this current scheme. Administrative requirements can either reinforce or defeat the potential of market mechanisms and incentives. In designing a regulatory administrative experiment, it is essential to understand the way in which EPA's administrative requirements actually work in the industrial domain as well as within the agency and state settings.

Volume 6 of the series, Innovation by Regulation: The Administration of Control Technology Requirements Under the Clean Air Act, by William Foskett, Adrienne Jamieson and Jay Evans, (NBS-GCR-ETIP 81-93), March 1981, concludes that the control technology requirements do not continuously rachet emission limits upwards as a result of technical improvements or air quality demands. Instead, Federal minimums tend to become maximums, particularly in the case of new source performance standards (NSPS). The theory explicit in NSPS is that review every four years of the standards should yield information on technological advances beyond the original base technology. In fact, revisions are seldom made in the standards to accommodate such advances. It is unclear whether this is attributable to the non-existence of such advances or the fact they are overlooked in the review. This question is discussed separately in more detail in Volume 7 of the series, Periodic Review and Technological Escalation of Performance Standards: New Source Performance Standards Review Process, by William Foskett and Terry Olesen (NBS-GCR-ETIP 81-94), December 1980. Innovation by Regulation concludes that technological advances may go undetected, in part, as a result of breakdowns in the current system's information feedback. On the other hand, technological advances may not occur at all due to the lack of positive incentives and to lengthy administrative complexities in implementing the Act.

An example of these administrative complexities is treated separately in Volume 8 of the series, Controlled Trading and Site Specific SIP Revisions: Competing for Attention in Crowded Administrative Routes, by Jay Evans (NBS-GCR-ETIP 81-95), December 1980. This administrative route is particularly important to the experiment in incentives because

controlled trading initiatives must be cycled through the SIP revision process. That is to say, each state implementation plan (SIP) must incorporate all requests for the use of controlled trading. By the end of 1980 the number of external offsets and "bubbles" processed were minuscule compared to all state-wide SIP revisions and site-specific variances. The degree to which this comparatively infrequent use of available controlled trading options is a function of industry restraint is not known. The case studies in Volume 8 make it seem probable that industry restraint is based on a perception that being caught in the SIP revision process is a low yield proposition. To change this perception that report suggests clearer guidance by EPA, greater delegation of authority to states, streamlining the SIP revision process and allocation of priorities to innovation-oriented initiatives.

Volume 9 of the series is a discussion of internal offsets. An internal offset occurs when a regulated firm obtains emission reductions from existing nearby sources that are under the control of that same company. If, for example, an industrial firm decides to build a major new unit in an existing plant within a nonattainment area, it may do so if it reduces emissions in other parts of the existing plant or in nearby plants that it owns. Volume 9 presents information on six cases involving internal offsets by firms, paying special attention to possible effects of internal offsets on technological innovation. The analysis discusses the lack of a theoretical framework to measure the extent and worth of innovation impacts and shows the difficulties involved in relating these impacts causally to the government's offsets rulings.

Despite these difficulties, the report concludes that internal offsets are more innovation-encouraging than innovation-discouraging and lead to pollution reductions sooner than such reductions would occur otherwise.

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# INTERNAL OFFSETS AND TECHNOLOGICAL INNOVATION:

# SIX CASE STUDIES

by

Mary Ellen Mogee

April 1982

Experimental Technology Incentives Program

## Acknowledgments

The Experimental Technology Incentives Program (ETIP) operates on the principle that, with information on the actual impacts of government programs on the private sector, those programs can be altered in a way that reduces burdens and allows increased productivity and innovation. This requires open and frank communication between the public and private sectors. The author would like to thank the individuals and firms who discussed their experiences with internal offsets and gave of their time to review interview notes. Without their cooperation it would have been impossible to conduct this study.

## Executive Summary


Internal offsets are one of a family of emissions trading concepts administered by EPA that allows sources to trade reductions in air pollution control where the per-pound cost of control is high for increases in control of the same pollutant where the per-pound cost of control is low. Offsets were introduced in 1976* as a means to allow continued economic growth in nonattainment areas while preserving progress toward attainment. EPA also expects that, in the long run, emissions trading (including internal offsets) will stimulate innovation in pollution control and process technology by "making it profitable for firms to create more reductions than the law now requires."**

This report looks at experiences of six industrial firms with EPA's internal offsets policy. It pays special attention to possible effects of internal offsets on technological innovation. Case studies of the actual use of these policies were conducted at four petroleum refineries and two automobile manufacturers:

- o TOSCO's Avon Refinery -- Martinez, California
- o Gulf Oil's Port Arthur Refinery -- Port Arthur, Texas
- o Marion Refinery -- Theodore, Alabama
- o Shell Oil's Martinez Refinery -- Martinez, Calfifornia
- o General Motors Painting Facility -- Pontiac, Michigan
- o Ford Motor Company Mt. Clemens Vinyl Plant -- Mt. Clemens, Michigan

The cases are described in the report and brief conclusions are presented in the final chapter.


Note: Footnotes appear in back of book.

Innovation -- defined as technology perceived by the companies to be new or little-used -- occurred in several of the cases examined. Some of the innovations occurred in the new sources or major modifications that were being constructed; others were installed in the existing plant to create an internal offset. Some of the innovations were in the technology involved in the production process of the company (e.g., Shell's Flexicoker); others were in the technology for controlling emissions from the process (e.g., Marion's barge vapor flare).

Although the evidence from these cases is necessarily preliminary and limited, internal offsets appeared to promote technological innovation in several ways. Some companies in the cases installed innovative technology to make the internal offsets. That is, given the requirement to reduce emissions in the existing plant in order to be allowed to build a new plant, some firms chose to use innovative technology to reduce those emissions. The primary example of this was Marion's barge vapor flare. More importantly however, the internal offsets policy promoted innovation in these cases by allowing the firms to build new sources or make major modifications in nonattainment areas, which would otherwise be prohibited under the Clean Air Act. In so doing, it allowed the companies to install additional plant and equipment, which often embodied innovative process and/or control technology--replacing old, inefficient equipment that had higher emissions. Examples of innovations occurring in this manner are the Shell Flexicoker and the Avon catalytic reformer.

Despite the apparent relationships suggested by our study, many of the companies expressed the belief that there is no connection between internal offsets and technological innovation. They did not view innovation as a goal of the internal offsets policy, but rather saw the primary goal of the policy as air quality improvement. Those who believed that innovation may result from internal offsets, regarded this as a by-product of the policy. One company commented that internal offsets may stimulate innovation over time as the potential supply of internal emissions reductions declines and the firm must consider new ways of achieving internal offsets.

In addition to providing some evidence, albeit preliminary and limited, on the relationship between internal offsets and technological innovation, these case studies raise further questions. Some of these questions pertain to the definition and measurement of technological innovation. Others pertain to the difficulty of establishing cause-and-effect relationships between public policies and phenomena in the private sector. Still others pertain to the wisdom and feasibility of separating internal offsets from the context of command and control regulations and the other emissions trading concepts with respect to their effects on innovation.

The report concludes that internal offsets are more innovation-encouraging than innovation-discouraging and lead to pollution reductions sooner than those reductions would occur otherwise.

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# INTRODUCTION

Over the past several years there has been increasing interest among students and practitioners of environmental regulation in the use of economic incentives in place of the traditional "command and control" regulations now widely in place. The general idea is that through the use of economic incentives more efficient pollution control will be achieved. In addition, it is often postulated that more technological innovation will be stimulated by the use of economic incentives than by command/control regulation. This would be desirable for at least two reasons: (1) Increased technological innovation is widely believed to be necessary to improve industrial productivity, international trade competitiveness, and generally better performance of the U.S. economy, (2) Technological innovation is viewed as an important and perhaps crucial element in achieving national environmental goals.

The Environmental Protection Agency (EPA) has developed a family of market mechanisms for air pollution control under the rubric of "emissions trading." The concepts include internal offsets, external offsets, and bubble.

The Experimental Technology Incentives Program (ETIP) of the U.S. National Bureau of Standards is cooperating with EPA in the development and implementation of these emissions trading concepts. ETIP's mission is to assist other Federal agencies in making and evaluating policy or program changes that will result in the stimulation of, or removal of barriers to, technological innovation. In the context of EPA's emissions trading concepts project, ETIP has contributed a series of background reports, of which this is one.

This report describes experiences of six industrial firms with internal offsets and pays special attention to possible relationships between internal offsets and technological innovation.

## INTERNAL OFFSETS

The Clean Air Act Amendments of 1970 authorized the EPA to establish National Ambient Air Quality Standards (NAAQS) for six common pollutants. It also required each State to develop, promulgate, and implement a State Implementation Plan (SIP) to bring the air quality of every area of the State into conformance with the NAAQS within a specified period. Each SIP was required to include a new source review procedure to prevent construction of new or modified stationary air pollution sources which, when operated, would interfere with the attainment or main-tenance of NAAQS.

By 1976, the attainment dates for the NAAQS had passed and many areas had not yet achieved the standards. Thus the Clean Air Act in principle could have prohibited the construction of new emission sources and, hence, industrial growth in many areas.

In December 1976, EPA issued an Emission Offsets Interpretative Ruling (EOIR) which described certain conditions under which the States could permit the construction of new or modified stationary sources which would introduce new air pollution in a nonattainment region.[1/] Simplified, these conditions were:

(1) Either the rate of emission of the pollutants by the source does not exceed designated limits ("not a major source");

(2) or, if the rate does exceed these limits:

a. The technology utilized in the new or modified source attains the Lowest Achievable Emission Rate (LAER) for the type of source;

b. All other nearby existing sources controlled by the operator are in compliance with all applicable air quality requirements and orders;

c. The operator makes an enforceable commitment to reconstruct or to change operation of some other existing nearby source, controlled by itself or others, so as to reduce total emissions from the other existing sources by an amount more than the maximum emission rate permitted by the state from the new or modified source. The reduction obtained by this commitment ("the offset") must be sufficient compared to the emission from the new or modified source so that "reasonable further progress" towards attainment of the NAAQS is accomplished in the affected areas; and

d. The offset must provide a net air quality benefit to the affected area.[2/]

The offsets policy -- internal and external -- allows new sources or major modifications of existing sources to be constructed in nonattainment areas by securing emissions reductions from existing nearby sources. An internal offset occurs when the regulatee obtains emissions reductions from existing nearby sources that are under the control of the same company. For example, if an industrial firm decides to build a major new unit in an existing plant in a nonattainment area, it may do so if it reduces emissions in other parts of the existing plant or in other nearby plants that it owns. The offsets policy applies only to the same type of pollutants. Thus, new sulfur dioxide emissions must be offset by reductions in existing sulfur dioxide emissions.

The principles of the EOIR were incorporated subsequently into the Clean Air Act Amendments of 1977.[3/] By January 1981 nearly 1,000 offsets had been approved and almost 95 percent of them were internal offsets.[4/]

Offsets were originally intended as a mechanism to allow continued industrial growth in nonattainment areas while preserving progress toward attainment.[5/] EPA also expects that, in the long run, emissions trading (which includes internal offsets) will stimulate innovation in pollution control and process technology by "making it profitable for firms to create more reductions than the law now requires.[6/]

## THE CASES

The six cases chosen for study were selected from a list of offset cases compiled by Vivien and Hall.[7/] This listing, which is periodically updated, is currently the most comprehensive listing to our knowledge.

Several criteria were used in selecting the cases. First, cases were limited to those that at least involved hydrocarbon pollutants. (Several cases included offsets involving additional pollutants.) The rationale for this decision was that process and control technologies associated with different pollutants would probably be so different that no meaningful comparisons could be drawn across cases. Second, cases were selected that represented two industries--petroleum refining and auto manufacturing--in order to allow comparisons within and between industries. Third, an attempt was made to include some cases that involved the use of new technology to make the offset. Fourth, cases were selected from different states because implementation of internal offsets occurs largely at the state level and provisions differ from state to state. Finally, cases were only included if a permit had been approved.

Data were collected by site visits at the firms and interviews with employees. Where possible, written documents were obtained from the firms to validate or expand upon the interviews. Interview notes were corrected and/or confirmed by the firms, and the case studies are based almost entirely on these confirmed interview notes. Interviews were not as a rule conducted with the regulatory authorities involved in the cases; thus the cases reflect primarily industry perspectives.

The following are brief descriptions of the six cases:

## 1. Avon Refinery No. 3 Catalytic Reformer

TOSCO's Avon Refinery, in Martinez, California submitted a preconstruction permit application for a new catalytic reformer in August 1978. Emissions offsets were provided for hydrocarbons, as well as sulfur dioxide ($SO_2$), nitrogen oxides (NOx), and particulates, through changes instituted in other parts of the refinery. The permit was approved by the Bay Area Air Quality Management District (BAAQMD) in December 1978, substantially as submitted.

## 2. Gulf Oil Port Arthur Refinery

Gulf Oil submitted a permit application for modification of a solvent dewaxing unit at its Port Arthur, Texas refinery in November 1978, as part of a major program of expansion at the refinery. The hydrocarbon emission offset was provided by retiring older units. Excess reductions were applied to other projects in the expansion program. The permit was approved by the Texas Air Control Board in May 1979, substantially as submitted.

## 3. Marion Refinery Hydrodesulfurization and Fractionation Unit

In August 1978 Marion Refinery of Theodore, Alabama submitted a permit application for a new hydrodesulfurization and fractionation unit. The refinery proposed to make hydrocarbon emission offsets by flaring fumes from its barge-loading operations. The permit was approved by the Alabama Air Pollution Control Commission and the EPA in June 1979, after some negotiations and revisions.

## 4. Shell Oil Martinez Modernization Project

Shell Oil applied for a permit for a major modernization project at its Martinez, California refinery in November 1978. One of the units to be constructed, a Flexicoker, will be the first of its kind to operate in the United States. Emission offsets were provided in a variety of

ways, including retiring old units and installing vapor collection and recovery systems on existing storage tanks. The permit was approved by the BAAQMD and the EPA in May 1980, after much negotiation and submittal of a new application.

5. General Motors Painting Facility

In early 1977 GM applied for a permit to construct a new painting facility in Pontiac, Michigan. Most of the hydrocarbon emission offsets were provided by switching a flow-coater in another GM division from solvent-based paint to water-based paint. The permit was approved in June 1977 after some negotiation.

6. Ford Motor Company Mt. Clemens Vinyl Plant

Ground had been broken and the equipment ordered for a new printer at the Ford Motor Company Mt. Clemens Vinyl Plant when the EOIR was issued in December 1976. Therefore, the Michigan Department of Natural Resources allowed Ford a half year to install LAER on the new printer. During this time, Ford made a large excess offset for emissions from the printer by shutting down a painting operation elsewhere in the Paint, Plastics, and Vinyl (PPV) Division and by retiring an older printer at the Vinyl Plant. After installation of LAER, the remaining emissions were permanently offset and the excess offsets were applied against an expansion program at another plant in the PPV division.

The detailed case descriptions follow.

# AVON REFINERY NO. 3 CATALYTIC REFORMER

## I. Background

The Avon Refinery in Martinez, California was built in 1913 and today is primarily a fuel producer. It is currently certified by the Department of Energy for 26,000 barrels per day (b/d). The refinery is owned by TOSCO, which also owns two other refineries, coal operations in Pennsylvania, and oil shale operations in Colorado and Utah. The Bay Area is nonattainment for ozone and some parts of it are nonattainment for particulates and carbon monoxide. It is attainment for sulfur dioxide and nitrogen oxides.

The decision to install the new No. 3 Catalytic Reformer was essentially forced by the lead-in-gas phase-down regulations. As lead is phased out of gasoline, the only alternative method of increasing the octane of gasoline is to "reform" it, a process that reforms the naphthenic molecules in the gasoline to aromatic molecules, which increases the octane. The lead phase-out regulations came into effect in 1976. The refinery decided to install the new catalytic reformer in December 1977 and contracted with Universal Oil Products (UOP) to design the new unit in February 1978.

## II. The New Source

Catalytic reforming "is not new technology," according to our contact; it has been in use since the early 1950s. The Avon refinery had two other catalytic reformers, but the new one is a "slightly different design." One of the older catalytic reformers was retired. The other is to be used as needed. The older units had three reactors with fixed platinum catalyst beds. During operation, coke would gradually build up on the catalyst, so the reactors would have to be shut down periodically and the coke burnt off. As the coke built up, reactor temperatures had to be raised and yield rates and octane number would fall. The new unit has four reactors arranged vertically with a moving-bed catalyst.

The catalyst is continuously removed from the reactors, regenerated, and returned to the top, from where it flows down by gravity. This eliminates the need for periodic down-time, keeps yield up, allows temperature to be kept constant, and produces a constant octane number product.

The catalyst regeneration technology in the No. 3 reformer was new to the Avon refinery and to TOSCO. There are similar units operating elsewhere in the United States; however, they were not in widespread use at the time it was decided to install the Avon unit.

The new regeneration technology was chosen by the refinery process engineering group, who studied it and then proposed it for the Avon project.

Our contact stated that pollution control regulations had no effect on this choice of technology. It depended solely on considerations of economics, product quality, and ease of operations.

Sulfur dioxide ($SO_2$) emissions from the reformer are controlled with an existing diethylamine (DEA) absorber system. The DEA absorber technology is "nothing new." NOx emissions are being controlled through the use of very low-NOx burners. By using these burners, the refinery could keep NOx emissions low enough not to trigger a PSD (Prevention of Significant Deterioration) review. The burners, which are made by a British firm, had been full-scale tested, but our contact was not sure whether any actual installations were in place when Avon ordered them. Hydrocarbon emissions were controlled with mechanical seals on all pumps and centrifugal compressors; this technology was already in extensive use at the Avon refinery and other refineries.

## III. The Preconstruction Permit

In December 1977 the California Air Resources Board adopted a New Source Review rule for the Bay Area Air Quality Management District

(BAAQMD). The application for the No. 3 catalytic reformer was considered under this rule. Under the rule, the project could be approved if there was no net increase in any pollutant for the refinery and BACT (Best Available Control Technology) was applied to the modification. If the project showed a net increase of more than 250 pounds per day for the refinery for any contaminant for which there was an ambient air quality standard, then Section 1309 applied, which required air quality modeling and external offsets for any excess over 250 pounds per day. This rule acted as a "driving force on technological change" by giving industry an incentive to submit applications for projects with no net increases or even reductions in emissions for the refinery as a whole.

The No. 3 catalytic reformer was considered under Section 1308 because the project, when offset by emissions reductions elsewhere in the refinery, would result in no net increase in emissions. Thus, according to our contact, it required LAER or BACT, depending on the pollutant, but it did not require air quality modeling or external offsets.

TOSCO applied for a construction permit on August 7, 1978. The permit was approved by EPA Region IX on December 18, 1978, and by BAAQMD on December 20, 1978. The construction permit automatically becomes an operating permit, upon completion of construction, until the BAAQMD cancels it or issues a new operating permit.

The refinery dealt primarily with the BAAQMD and somewhat with the EPA regional office in the permitting process. Generally, the refinery does not deal with EPA, but in this case the corporate TOSCO people noted that additional NOx levels from the new unit might trigger a requirement for EPA review under PSD rules. Therefore they sent the permit application to EPA for information purposes. EPA in turn issued authorization to go ahead with the project subject only to a requirement that NOx emissions not exceed a certain level.

## IV. The Internal Offsets

The internal offsets proposed by TOSCO were identified by the engineer who prepared the application, based on his knowledge of refinery emissions. The offsets were approved as proposed by the refinery, with the exception of the offset for hydrocarbon as explained below.

The $SO_2$ emissions were offset by reducing the sulfur content of the fuel oil used in other parts of the refinery. Particulates were offset by improving the electrostatic precipitator on the coker; these changes were proprietary to the precipitator manufacturer.

Nitrogen oxide (NOx) emissions were offset by continuous oxygen analysis in process furnaces throughout the refinery. NOx emissions from combustion can be reduced by not allowing excess air (oxygen) in the combustion chamber. If the precisely correct (stoichiometric) amount of oxygen is present, flue gas should contain no oxygen ($O_2$), but some nitrogen ($N_2$). If there is excess oxygen, some $O_2$ will remain in the flue gas, carbon monoxide (CO) and nitrogen oxides (NOx) are formed, and fuel is wasted. For years, industry (including the Avon refinery) has attempted to minimize excess oxygen in combustion in an effort to conserve fuel.

The methods previously used to analyze the oxygen content of furnaces at the refinery used a piece of equipment called a Fyrite. Flue gas sample was mixed with a liquid, which indicated the oxygen content of the gas. Then the damper on the furnace was adjusted to increase/decrease the supply of air. The process, which was done once a shift, did not result in very close control of the oxygen content.

The new oxygen analyzers allow the operators to monitor the oxygen content of the flue gas continuously and to adjust the dampers more often. The new system is much easier to operate. The refinery management felt the continuous analyzers would pay for themselves by reducing fuel usage. The continuous oxygen analysis technology installed was

already in extensive use in the Avon refinery and other refineries. The District agreed to this offset without requiring documentation of NOx emission levels before and after installation of the continuous analyzers.

To offset hydrocarbon emissions, the refinery first proposed to install mechanical seals on many pumps throughout the refinery. On further inspection, however, it was found that some of these pumps were not used full-time. Therefore, the refinery reproposed to use hydrocarbon credits created earlier and reported to the District. These credits had been obtained previously when the refinery had installed hydrocarbon controls beyond that required by regulations.

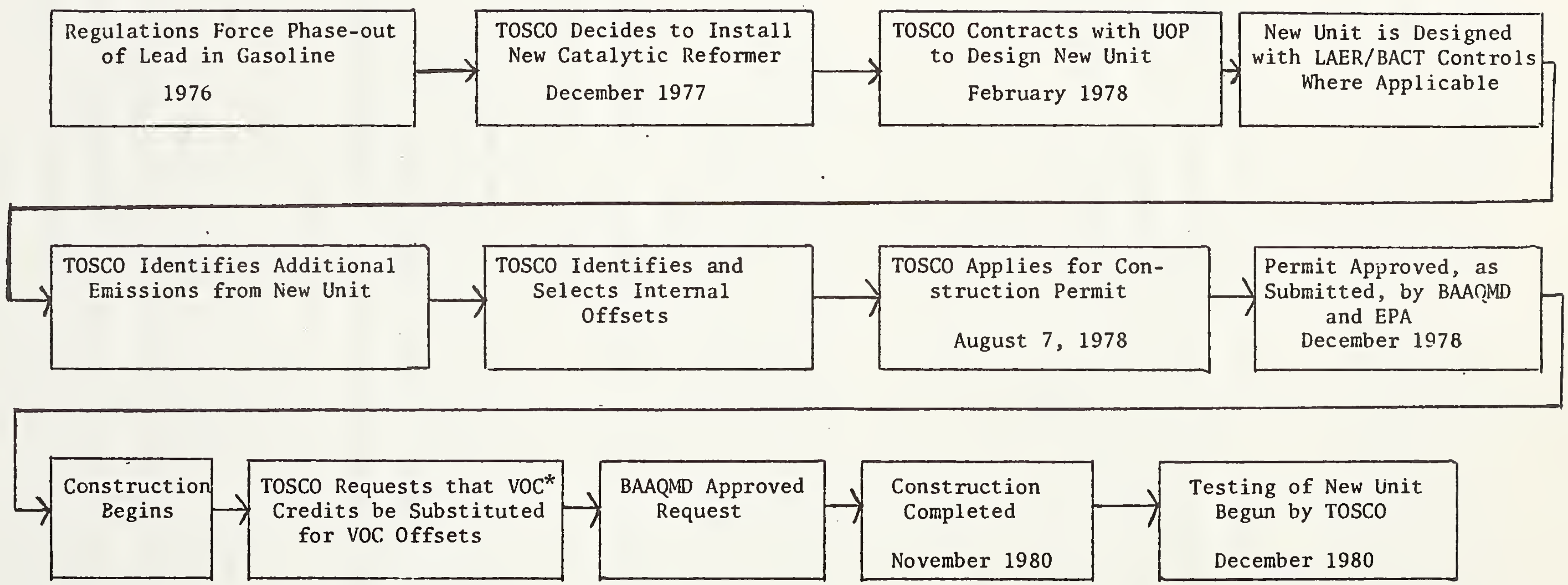
## V. Summary

Figure 1 diagrams the step-by-step process involved in the Avon refinery's internal offset for its No. 3 catalytic reformer. The process is shown beginning with the lead-in-gasoline phase-out regulations in 1976, which created the need for a new reformer. The new unit was designed with emissions controls that met LAER/BACT requirements where applicable. Uncontrolled emissions in the rest of the plant were identified to offset the remaining emissions from the proposed reformer. The permit was applied for in August 1978 and approved in December 1978. Subsequently, the refinery requested that hydrocarbon credits be substituted for the proposed hydrocarbon offset, a request which was approved. At the time of our interview, the newly-constructed unit was undergoing initial testing.

In the Avon case, innovation occurred in the new catalytic reformer unit being constructed and the very low-NOx burners on the unit. The internal offsets policy did not stimulate those innovations, but enabled them by allowing the new unit to be built. The new unit was stimulated by the lead-in-gas regulations. The offsets did not involve the use of new technology.

Figure 1

TOSCO AVON REFINERY CASE




* VOC = Volatile Organic Compounds

GULF OIL PORT ARTHUR REFINERY

## I. Background

This case concerns modification of a solvent dewaxing unit (SDU) at the Gulf Oil Refinery in Port Arthur, Texas. The Port Arthur Refinery is part of the Gulf Oil Refinery and Marketing Company (GORAM), which is headquartered in Houston. GORAM, in turn, is a division of Gulf Oil Corporation which has its headquarters in Pittsburgh, Pennsylvania. Port Arthur is the largest of Gulf's seven domestic refineries. It has a design capacity of 340,000 barrels per day and manufactures a wide range of petroleum and petrochemical products including gasoline, kerosene, lubrication oil, jet fuel, ethylene, and others. Although some portions of the plant are quite old (built in the 1920s) the plant has had a continual upgrading program throughout the years. The Port Arthur/Beaumont, Texas area is nonattainment with respect to hydrocarbons.

Gulf Oil is in the process of a major program of expansion at the Port Arthur refinery, called the Crude and Lube Enhancement Program.[8/] The purpose of the program is to increase the refinery's ability to refine inferior heavy and "sour" (high-sulfur) crude oil. Currently, light, "sweet" (low-sulfur) crudes are declining in availability and going up in price. These trends are expected to continue as foreign crude oil supply countries develop their heavier type crude oil reserves earlier than previously indicated. The Port Arthur refinery currently has sour crude capacity of 150,000 barrels per day. This capacity will be increased, giving the refinery more flexibility to refine a variety of crude oil types and quality. The program will also achieve savings of refinery fuel usage and allow production of lube oils from sour crudes, which is not currently possible.

## II. Modification of Solvent Dewaxing Unit

Most crude oil contains wax. Lubricating oils are distillates recovered from the crude oil which are further refined in several lube

oil processing steps. The wax must be removed from these distillates before they become acceptable lubricating oils. This is done by mixing the distillates with a solvent mixture and cooling it to the temperature at which the wax crystallizes out, using heat exchange and propane refrigeration. The wax crystals are removed from the oil in rotary vacuum filters and the wax cake is recrystallized and filtered again to remove excess oil. The dewaxed oil and wax streams are stripped of solvent before leaving the unit as products.

Gulf Oil proposed to modify the solvent dewaxing unit (SDU 1943) by installing two Dilchill Crystallizers for the purpose of forming wax crystals in the lube oil being processed. The Dilchill Crystallizers would take the place of 12 banks of scraped-surface, double-pipe exchangers. In addition, a solvent fractionation tower and a dehydration tower were to be installed in order to adjust solvent composition and remove water from the solvent.

The main objective of the Dilchill conversion is to allow Gulf to maintain present lubricating oil production rates as lube oil distillate quality declines. Lower quality distillates with higher wax contents will be processed by the unit, but the increased filtration rates afforded by the new equipment will allow an increase in throughput and roughly the same production of dewaxed oil product. Processing the poorer distillates in the present facility would result in greater loss of product in the softwax stream which is routed to the catalytic cracking units. Dilchill would also reduce losses when processing the present lube distillates.

The Dilchill process was developed by Exxon around 1974. Exxon has at least two Dilchill Dewaxing Units and there are at least three others, including units owned by Gulf Oil Canada and China Gulf. The Dilchill process, according to our contact, "was selected as the best dewaxing process to meet Gulf's need of maintaining lube oil production rates as lube distillate quality continues its decline."

The crystallizers are completely self-contained and emissions can only escape through the one shaft seal in each crystallizer and the flanges where connecting pipes enter. To assure that the seals will not result in excessive emissions, the Texas Air Control Board (TACB) requires that emissions from the seals be periodically monitored. In addition, all safety valves installed on the modification are vented to a flare and all new pumps have double mechanical seals.

## III. The Preconstruction Permit

Because of the expansion program, the Port Arthur refinery was involved in a number of permit applications involving emission offsets. Phases I and II involved twelve permits, all of which have been obtained at the time of this writing. The SDU modification must be viewed within the context of the overall expansion program and the other permits.

The permit application for the SDU modification was submitted on November 7, 1978, to the TACB. (Gulf generally does not interact with the regional EPA office on offsets because Texas has authority to administer offsets under its approved SIP). In its application, Gulf Oil proposed the installation of the Dilchill Crystallizers as described above and proposed shutting down 12 banks of old scraped-surface double-pipe exchangers as the offset.

Using EPA emission factors, Gulf Oil calculated that the additional equipment due to the modification would create 8.8 tons per year additional hydrocarbon emissions. The 12 banks of scraped-surface double-pipe exchangers being replaced would supply 131.4 tons per year of hydrocarbon offsets. Assuming a required offset ratio of 1.1 to 1.0, Gulf was left with 121.7 tons per year in excess hydrocarbon offsets. The excess offsets were reserved for application to other permitted projects at the refinery that were part of the expansion program. A formal system of banking and credit is not operating in the state. Instead, both the refinery and the TACB keep records of cumulative permitted emission additions and reductions and the permits cross-reference each other so that excess reductions in one can be used to offset new emissions in another.

The TACB had some questions about details of the application, but no major objections, and no objections at all to the proposed offsets.

Gulf Oil did not include in its application any reference to LAER technologies, such as venting safety valves to a flare and putting double mechanical seals on all pumps. These were added by the TACB in the form of general provisions as conditions for the permit, as is their usual practice. These general provisions pertain to safety features and emissions control. Whereas the TACB general provisions previously specified, for example, double-mechanical seals on all pumps, they are now more general and pertain to the detection and prevention of leaks. Our contact thought that the TACB had probably responded to pump seal manufacturers and possibly some industry people who feel that in many applications a single seal can do as well as a double seal.

The permit was approved on May 2, 1979. Construction began March 12, 1980, and was expected to be completed in February 1981. No reason was given for the apparent delay in beginning construction. It may have been due to the timing of the overall expansion program.

## IV. The Internal Offsets

The offsets were obtained by shutting down part of the old process which was inefficient and high in emissions. The replaced equipment consisted of 12 banks of scraped-surface, double-pipe exchangers. Each bank of these old scrapers had 12 shafts with packing glands through which relatively high levels of emissions escaped. By eliminating 12 banks of scrapers, 144 packing glands were eliminated. The equipment replaced was about 20 years old.

Although the offsets provisions was not a major consideration in Gulf Oil's decision on this modification, according to our contact, it certainly was a definite "plus" for the project. In order to obtain the offsets needed for a large program of expansion, Gulf had an incentive

to retire equipment with high emission levels. In the case of the SDU there was an incentive to reduce emissions from the old plant much more than necessary to offset the new emissions from the SDU modification.

## V. Perceived Problems with Internal Offsets

In general, our contact did not perceive significant problems with the offset provisions in the SDU case. He noted that Gulf Oil had attempted to anticipate regulatory requirements in formulating the proposal and the permit application.

The primary problem to date with offsets as administered by the State, according to our contact, has been timing. The offsets submitted for any particular permit must be accomplished prior to the placing in operation of the permit unit. This requires close attention to the offsets proposed for a permit to assure that the timing is proper.

In addition, it is necessary that the reductions submitted for a permit be ones which are not required by regulations. Some problems have been encountered with reductions which were actually made prior to the effective date of regulations that would require such reductions. In some cases such reductions have been disallowed by the TACB, which stated that the permit for which the reductions were submitted must have been issued prior to the effective date of the regulations requiring such reductions. Gulf maintains that as long as the reductions were actually accomplished prior to the effective date of the regulations, then the permit issue date should be immaterial.

## VI. Summary

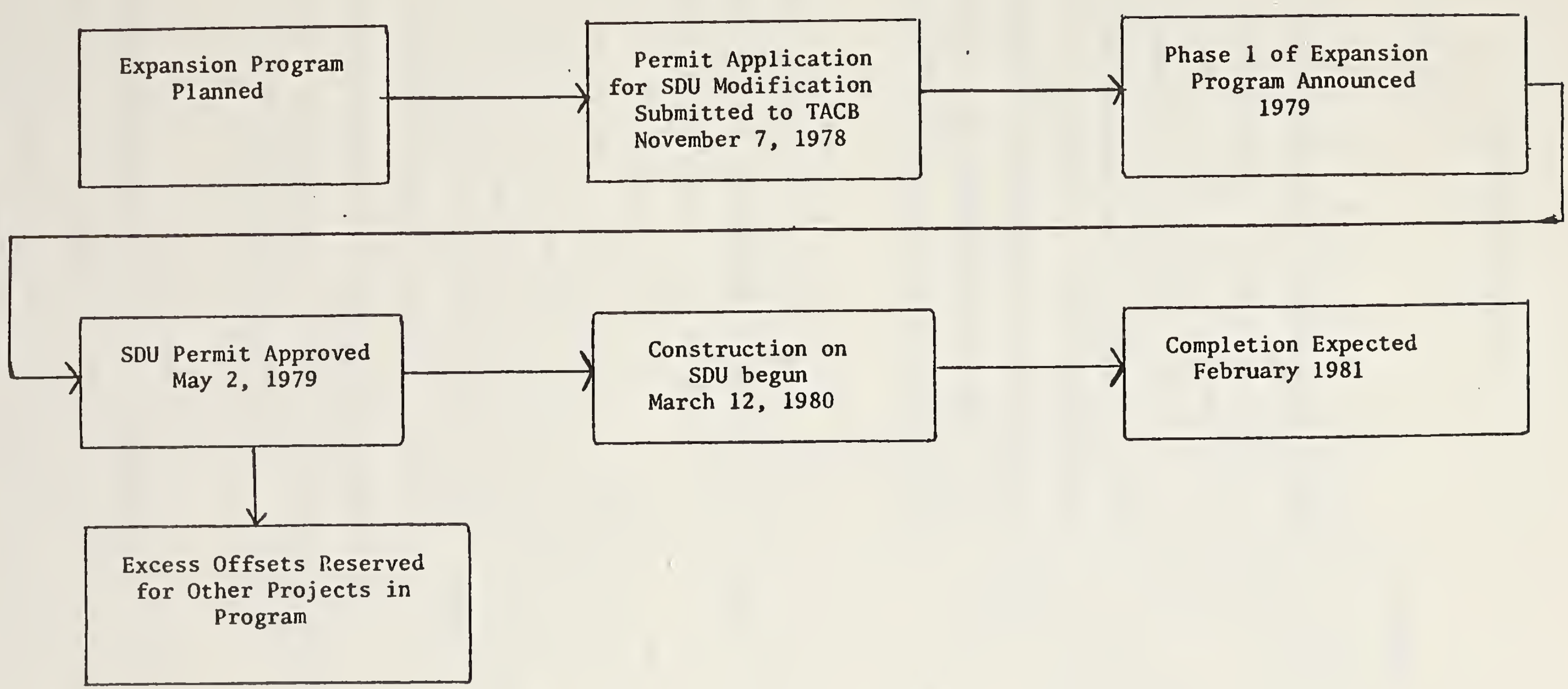
Figure 2 diagrams the major steps in the internal offsets process for the SDU modification. The process was initiated when GORAM headquarters decided upon the expansion program at the Port Arthur refinery. The permit application for the SDU modification was submitted on November 7, 1978. In this case there was no real search for internal offsets

in the usual sense, since the modification involved replacing the old equipment and using their emissions as offsets. Applications for other permits required for Phase I of the expansion program were also submitted around the same time. The expansion program was officially announced by Gulf in 1979. The SDU permit was approved on May 2, 1979 and the excess offsets from the modification were reserved for use on other projects in the program. Construction was begun on the SDU on March 12, 1980 and it was expected to be completed in February 1981.

In the Gulf case the conversion to Dilchill crystallizers, which represent fairly new technology, was stimulated by the refinery's need to maintain production as the quality of feedstocks declines. The offsets were obtained by retiring the old units which the Dilchill Crystallizers were replacing. It could be argued that the old units would have been replaced anyway, but it is impossible to say when. The offsets policy was not a major factor, but it was a definite "plus" in the decision to make the conversion. It gave Gulf the incentive to retire old, highly emitting equipment earlier and to reduce emissions more than the company probably would have done otherwise.

Figure 2

GULF OIL PORT ARTHUR REFINERY INTERNAL OFFSET



# MARION REFINERY

## I. Background

Marion Corporation is a small, integrated oil operation with headquarters in Baldwin County, Alabama. Its activities include exploration, drilling, refining, refined product sales, crude purchasing, and coal. Its only refinery is located in Theodore, Alabama in Mobile County. It is a small refinery, having processing capability of about 28,000 barrels per day and employing about 90 people. The refinery receives crude oil through a pipeline and processes it largely into LPG, jet fuel, gasoline, diesel fuel, and residual oil. Mobile County has been designated as a nonattainment area for ozone and as an attainment area for sulfur dioxide ($SO_2$).

The permit in this case was for the construction of a new hydrodesulfurization and fractionation unit at the refinery. Marion's decision to build the new unit resulted from a conjunction of events. In 1976 the refinery installed a Hydrofiner-Powerformer unit to desulfurize and reform the naphtha produced in the refinery to make unleaded gasoline. This process produces excess hydrogen as a reaction by-product. In 1977 Marion was made aware of a Condensate produced by a company in a nearby county. When desulfurized, the naphtha cut responded to lead (Pb) antiknock such that it could be used to produce leaded regular gasoline. The excess hydrogen available from the Hydrofiner-Powerformer could be used to desulfurize the Condensate. As a small refiner, Marion under the Clean Air Act provisions regarding lead in gasoline is able to put more lead in gasoline than larger refineries.

Marion studied the proposal for technical feasibility and economics. The J.E. Sirrine Co. was retained to do the engineering and cost evaluation on the proposal. The economics and feasibility of the proposal looked good, so the Marion Corporation decided to pursue it.

## II. The Preconstruction Permit

The preliminary application was submitted to the Alabama Air Pollution Control Commission (AAPCC) in August 1978. This preliminary application was lacking in certain areas and required additional study and data. The final application was submitted on January 24, 1979, jointly to the AAPCC and the Mobile County Public Health Department (MCPHD). Representatives of AAPCC and MCPHD discussed the proposal with Marion several times between August 1978 and mid-February 1979. After County and State review and acceptance, the County announced a 30-day public comment period followed by a public hearing scheduled for March 28, 1979. A copy of the permit request was also forwarded to EPA Region IV.

EPA's comments were in the form of a letter to Marion Corporation and referred mainly to the computer air quality modeling in the proposal. Their comments pertained to future applications and did not require changes in the Marion application.

At a meeting of representatives of EPA, AAPCC, and Marion that was held after the public hearing, the EPA representative announced that single-mechanical seals, as proposed by Marion, would not be sufficient to meet LAER requirements for hydrocarbons. EPA stipulated additional conditions for the permit based on a permit issued to a refinery in Texas. The additional EPA requirements included, among other items, double-mechanical seals on all pumps and a program of emission detection and maintenance, including repairing leaking pumps within five days.

Our contacts said the Texas requirements may have been an inappropriate comparison for the Marion refinery. Since the Texas plant might be handling heavier crude and certainly did not have a Hydrodesulfurizer unit at the front end of the process, it would have much less difficulty in achieving lower emissions than the Marion plant, which handles the light Condensate.

Marion objected to the additional LAER requirements on a number of grounds. Double-mechanical seals on pumps, they argued, cost considerably more than single mechanical seals but only improve emission reductions marginally. Moreover, fugitive emissions from process equipment are very small in relation to the total emissions from other refinery and natural sources. Although it is standard practice in the refinery to repair leaking pumps within five days, it might not be possible to meet this deadline if more than one pump went out at one time, without enlarging the maintenance staff. The detection equipment required for an emission detection program is expensive: One detector costs $15,000, requires specialized calibration, and cannot reach all the valves, flanges, and fittings that EPA wants tested. Marion suggested alternative aproaches to control which were not accepted by EPA. Marion finally agreed to EPA's LAER conditions on the new unit, because otherwise EPA would not sign the permit. EPA signed the permit on June 15, 1979.

In contrast to LAER, there was little disagreement over the proposed hydrocarbon (HC) offset.

## III. The New Source

The new hydrodesulfurization and fractionation (HDS) unit, which was put into operation on September 15, 1980, cost about $12 million. The unit is designed to process 5,000 barrels per day of feedstock and to produce 1,464,000 barrels per year of leaded gasoline, as well as smaller amounts of other products. HDS units of this kind are "very common refinery processing units," according to our contacts.

The major emissions from the proposed plant are $SO_2$ and hydrocarbons (HC). Marion proposed to remove the $SO_2$ through the use of a three-stage Claus unit. This was approved by the State and EPA as BACT. The three-stage Claus unit has been used extensively in similar applications, but had not been used by Marion before. The HC control technology is double-mechanical seals on all pumps, in accordance with the LAER determination. Double seals, according to our contacts, have been little used and have not been used in similar applications. They had not been used before by Marion.

The concept for the new unit was developed by Marion personnel with the engineering being done by J.E. Sirrine Co. Project management for the construction phase was also handled by Marion people.

Marion was given six months from the beginning of new plant operation to submit a plan for a program of emission detection and maintenance and to begin operating such a program. Marion was in the process of preparing a plan at the time of our interview.

## IV. The Internal Offsets

In general, the HC offset situation in Mobile County is very restrictive. In 1972 Mobile County required installation of floating roofs or a vapor collection and recovery system on all petroleum storage tanks containing a volatile organic compound. These regulations were later included in the SIP. They were far ahead of EPA regulations at the time. Due to the relatively tight HC controls previously installed by Mobile industry, HC offsets are now difficult, if not impossible to find. Marion considered going outside to buy or arrange external offsets, but they were not found to be available. Any firm in the Mobile area that provides offsets for another is essentially foregoing any future expansion of its own, according to our contacts.

To identify possible internal offsets, Sanders Engineering performed an inventory of all emissions at the Marion refinery and dock, using EPA emission factors. The inventory revealed that the only Marion refinery source that theoretically could provide the HC offset was the barge-loading operation, which was previously uncontrolled. During normal loading of current-design barges with refinery product, emissions escape from the barge via an opening in the deck of the barge (the ullage hole) due to displacement of the barge compartment vapor space with petroleum product. Marion proposed to install systems that would flare the vapor from the barge-loading operation. The system consists of a manifold on both sides of the dock which can be connected to a barge vapor header. Alternately, Marion can run a vapor hose into the ullage hole itself. The collected emissions are then led to the flare.

Marion chose to flare the collected vapors, rather than condense and save them, because it believed that the emissions that would be collected would not be enough to justify the more expensive vapor recovery system and also considering the fact that the docks are located three miles from the refinery. The Marion plant manager did not believe the EPA emission factors on barge-loading and noted that deficiencies in these factors had been brought out in recent trade literature articles.

To the knowledge of our contacts, this is the second flare installed for barge-loading application in the United States. The first one was installed in Houston and nearly caused an explosion, so its operation was discontinued. This type of flare has, however, been used extensively for other applications, especially truck loading. The flare cost about $150,000 to install. Marion retained a local engineering firm to design and engineer the system for construction bid purposes.

At the time of our interview, the flare was installed but was not yet in regular operation. The pilot system and blower had been tested and found to work. The U.S. Coast Guard (U.S.C.G.), which also has to approve the flare, was reviewing its design and installation from a safety viewpoint.

Most current-design barges do not have a barge vapor header, so in most cases the vapor hose must be run into the ullage hole itself. The ullage holes, however, are covered by screens that act as flame arresters, a safety feature. The U.S.C.G. has a regulation which does not permit removal of these screens during loading operations. Only one of the barges that load intermittently at the Marion refinery dock is equipped with a vapor header. Marion intended to try the system on that barge after U.S.C.G. safety approval. The refinery has no control over the barges, which are owned by several independent towing companies, to require retrofitting with headers. There is some possibility, however, that regulatory authorities (e.g., U.S.C.G., Department of Transportation) may require headers on barges in the future. Marion is also trying to find some means of collecting the vapors from individual compartments while avoiding the screen problem. This seemed unlikely, however, at the time of the interview.

## V. Perceived Problems with EPA Emission Factors

Our contacts noted that refiners have an economic incentive to minimize leaks or emissions, in the absence of regulation, because of the high cost of crude oil, refined products, and energy. They believed that the EPA Control Techniques Guidance emission factors for refinery operations are too high in some cases, referring to a case where an emission factor had recently been revised downward by a factor of 10,000. They said that if firms lost as much in emissions as EPA says, it would cost them millions of dollars per year. It is highly unlikely, they thought, that any firm would be unaware of such losses or would sustain them knowingly.

Nonetheless, HC emissions are difficult to detect and detection equipment is expensive. Marion and other small refiners do not currently have HC detection equipment, so their true HC emissions must remain uncertain. The emission inventory at Marion was done using EPA emission factors. Our contacts felt that it was not likely that EPA would have accepted an inventory based on measured emissions.

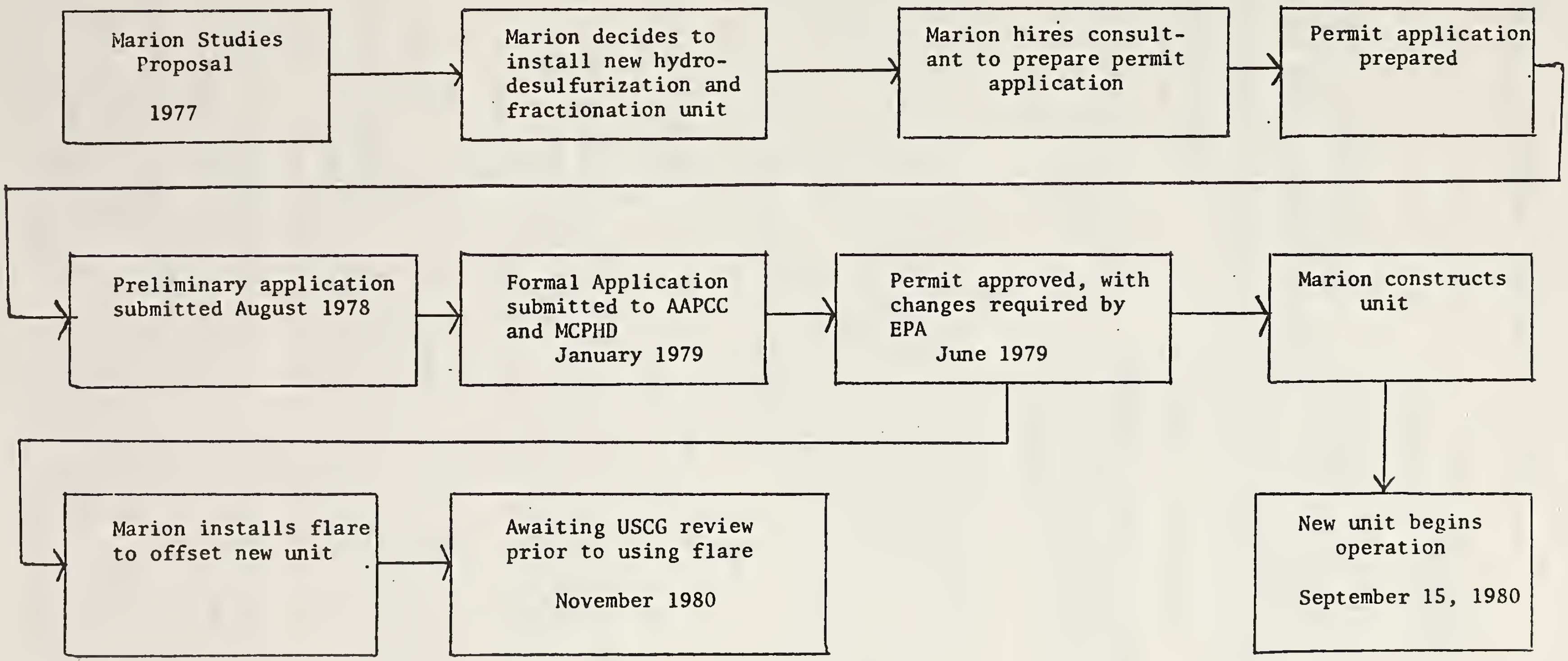
## VI. Summary

Figure 3 diagrams the steps in the internal offsets process for the Marion refinery HDS unit. The process began in 1977 when Marion corporate executives began to consider the proposal to install an HDS unit for processing the Condensate. After deciding on the project, Marion hired a consultant to prepare the permit application. The permit, after some revision, was formally submitted to the AAPCC and MCPHD in January 1979 and approved, with changes required by EPA, in June 1979. The new HDS unit was constructed and in operation by September 15, 1980. The barge vapor flare (the internal offset) was installed but had not been put into operation by the time of the interview (November 1980). Marion was awaiting a U.S.C.G. safety review prior to using the new flare system. It appeared at the time that U.S.C.G. safety regulations might limit the use of the flare.

In the Marion case, the firm installed technology that was new and uncertain -- i.e., a barge vapor flare -- to create the necessary offsets for the hydrodesulfurization and fractionation unit. The internal offsets policy clearly stimulated this innovation, because under current regulations the refinery would have no need to control emissions from barge-loading operations otherwise. The policy also gave the refinery the flexibility to choose a flare over a recovery and recycling system, which it did on primarily economic grounds. The risks involved in innovating are illustrated by the conflict with U.S.C.G. safety regulations and the associated delay in putting the flare into regular operation.

Figure 3

MARION REFINERY CASE



SHELL OIL MARTINEZ MODERNIZATION PROJECT

## I. Background

Shell Oil Company is a U.S. corporation with headquarters in Houston, Texas. Its Martinez, California refinery, most of which was built in 1966, produces 90,000 to 100,000 barrels per day of products--mostly gasoline, but some aviation turbine fuel, lube oils, asphalt, and residual fuel. The Martinez refinery is located in the Bay Area Air Quality Management District (BAAQMD), which is nonattainment for carbon monoxide, total suspended particulates, and ozone, and is in attainment for sulfur dioxide and nitrogen oxides.

The Martinez Modernization Project resulted from a business review conducted at Shell headquarters during the years 1974-1976. The review indicated that the refinery produced too much residual fuel and not enough gasoline. Residual fuel is a low-price product. The residual fuel produced at the Martinez refinery was high in sulfur content and therefore could not be sold to utilities, the primary users, in the State of California because of its sulfur-in-fuel regulations. The refinery also had high transportation and fuel costs. Moreover, it was recommended that the refinery switch from foreign crudes to domestic crudes. Therefore, it was decided that some type of modernization of the Martinez facilities was necessary.

Shell considered a number of options. One was to desulfurize the residual fuel. It was decided, however, that technology was not available that could accomplish the desired level of sulfur reduction at required capital and operating cost levels. Shell also considered installing a conventional, or delayed, coker, which uses a fixed-bed, cyclic process to convert residual fuel to lighter fuel products and solid coke. This would allow production of a high-price product (gasoline) from a low-cost feedstock (residual fuel), leading to considerable cost-savings. Shell decided against the conventional coker because it produces about 25 percent coke, which is a low-price product and difficult to sell.

## II. The New Source

Shell chose to install a "Flexicoker," a continuous, fluidized-bed process. The Flexicoker converts about 99 percent of the residual fuel to gaseous and liquid fuel products, leaving only about one percent solid coke. About 95 percent of the coke generated is gasified and, after desulfurizing, is used to fuel the refinery. The Flexicoker can also handle feedstocks with high metals and/or carbon content, which is typical of California crudes.

The Flexicoker process is licensed by Exxon Research and Engineering Company. Exxon had run a demonstration plant in the United States for two years. At the time Shell was considering installing one, however, the only operating unit was in Japan. The Japanese unit was just in its start-up phase and had broken down once. The Japanese application of the process was similar to that planned at Martinez and was of nearly the same size. Shell sent a number of people from the Engineering Department and the refinery to study the Japanese unit from the standpoints of process, operation, and mechanical engineering.

## III. The Preconstruction Permit

Shell applied for a preconstruction permit for the Martinez modernization for the first time in December 1978. They dealt primarily with the Bay Area Air Quality Management District (BAAQMD) and indirectly with the California Air Resources Board (CARB). Shell advised EPA's Region IX office of the project and sent them a copy of the application. Region IX responded that it was not necessary to apply for Prevention of Significant Deterioration (PSD) on $SO_2$ or NOx emissions.

The BAAQMD looked at the Martinez refinery as a bubble for purposes of the requirements. It focused on two physical locations -- the wharf and the process area -- and accepted offsets at the refinery for emissions at the wharf. The approach was to issue a construction permit for the entire project. As the units are completed they will be tested and issued permits to operate.

The BAAQMD was using a model New Source Review (NSR) rule formulated by the CARB. The model rule allowed no increases in any pollutant emissions on an average annual basis. It allowed levels to be exceeded momentarily, if they were offset at a certain ratio.

One of the primary issues for negotiation with the BAAQMD was how baseline emissions should be calculated. The firm believed the base-line should be the emissions for which they were currently permitted. The original Shell plan showed that after the modernization, the refinery would emit less of all pollutants than the levels previously permitted. The BAAQMD, however, declared that the baseline was the average of actual emissions over the past three years, which was lower than the permitted level.

Shell submitted a revised application in June 1979, in order to conform to the BAAQMD's definition of base-line emissions. The construction permit was issued on May 8, 1980, following the preparation and acceptance of an Environmental Impact Report and lengthy procedures for permit review. The permit included a number of conditions of constraint, including limits on how much product can be loaded at the wharf, limits on total fuel usage, limits on the throughput rate, and an emission auditing program.

BAAQMD Regulation 2, Rule 2 required Best Available Control Technology (BACT) on process heaters. The Flexicoker pitch heater was required to be equipped with low-NOx burners. The Flexicoker steam super heater was required to be equipped with low-NOx-emitting trifuel burners. The Flexicoker gasifier vents to a Stretford gas treater, which is BACT, and the coke storage bins and purge silo are controlled by a bag house, which is also BACT.

The low-NOx burners, according to our contacts, were in extensive use and had been used in other Shell refineries, but not at Martinez. The Stretford gas treater had been used little at that time, and had not been used at Martinez or other Shell refineries. Bag houses had been used extensively elsewhere, but not at Martinez. To the knowledge of our contact, these control technologies had not been used previously in a similar application (i.e.,on a Flexicoker).

## IV. The Internal Offsets

As offsets, the refinery was required to bring additional existing tanks into an existing vapor recovery system and new tanks were to be tied into a new vapor recovery system. The lube oil compounding unit was to be shut down and limits were placed on allowable sulfur content of fuel. Further, the allowable level of marine vessel traffic was decreased. According to our contacts, these methods of control had all been used extensively before at the Martinez refinery and elsewhere.

At the conclusion of the modernization, offset credit of about 250 tons per year of hydrocarbon (HC) emissions will be available. Shell will save this credit for later use or sale.

In California, firms must file an emission inventory every year. Firms may use either empirical testing or EPA emission factors. The measurements are not usually a source of controversy. The inventory provides a ready means of identifying possible sources of offsets.

Our contacts felt there is probably still some opportunity to reduce emissions further at the Martinez refinery. Nonetheless, they felt that internal sources would probably be insufficient for future expansion and it would be necessary to buy offsets on the outside.

## V. The Importance of Business Considerations

In the years after the 1973 Arab oil embargo, there was reduced new capital investment in the petroleum refining industry because of price regulations that kept down the price of petroleum products. By 1978, however, the situation had changed sufficiently that it appeared that Shell could profitably invest in modernizing the Martinez refinery. Our contacts stressed that major innovation requires investment in new plant and equipment, which embodies the new technology.

Our contacts did not believe that environmental regulation provided a significant incentive for installation of the Flexicoker. Rather they described the innovation as the result of a complex business decision-making process primarily motivated by the opportunity for a profitable venture in terms of upgrading low-valued residual products and increasing use of lower cost domestic heavy crudes. They said the major role played by environmental regulation in this case was to create uncertainty in the firm over whether necessary permits would be obtained.

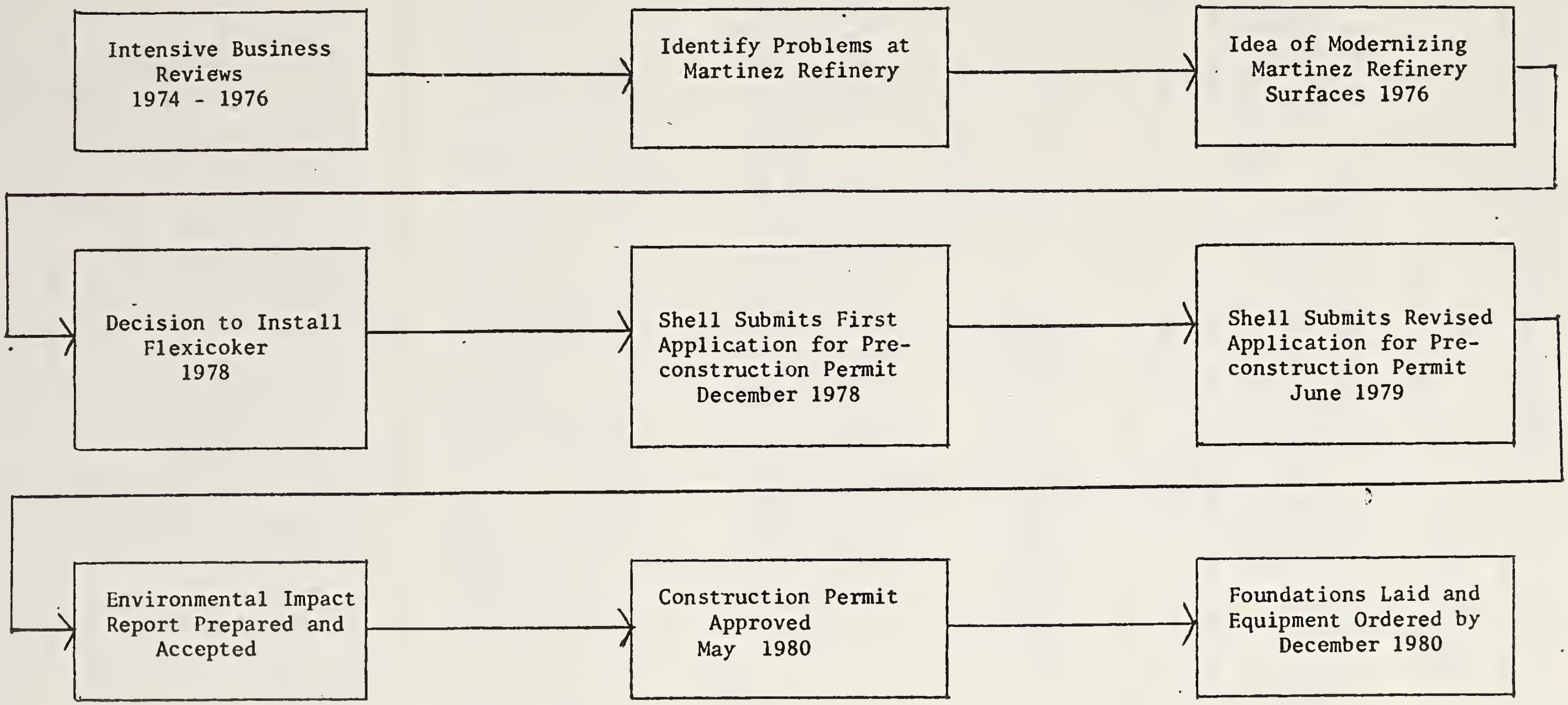
## VI. Summary

Figure 4 diagrams the major steps in the internal offsets process for the Shell Oil Martinez Flexicoker. The process began with a round of intensive business reviews at Shell headquarters, 1974-1976. The review identified certain problems at the Martinez refinery and the idea of modernizing the refinery surfaced in 1976. Shell first submitted its application for a preconstruction permit in December 1978; it submitted a revised application in June 1979 in order to conform to the BAAQMD's definition of baseline emissions. The permit was approved by May 1980, after the preparation and acceptance of an Environmental Impact Report and permit review. At the time of our interview in December 1980, the foundations had been laid and equipment ordered.

In the Shell case, new technology -- i.e., the Flexicoker -- was installed as part of the modernization project. Some of the reasons behind the modernization were the California sulfur-in-fuel regulations, the need to switch to domestic crudes, and the improved climate for investment. The Flexicoker was chosen over a conventional coker because of its economic superiority. New technology was not involved in making the offsets. The offsets policy in this case did not stimulate innovation, but enabled it to happen, by allowing the new unit to be built. From the point of view of the firm, however, environmental regulations on the whole discouraged the modernization project by increasing the uncertainty about whether it could be completed and put into operation.

Figure 4

SHELL OIL MARTINEZ MODERNIZATION PROJECT



## GENERAL MOTORS PAINTING FACILITY

### I. Background

In early 1977, after the EPA Emissions Offset Interpretative Ruling, General Motors (GM) applied for a permit to construct a new van painting facility in Pontiac, Michigan. The new facility consisted of a new building and equipment at an existing site. Some parts of an older building and some older equipment were also used. The purpose of the expansion was to add production capacity.

### II. The Preconstruction Permit

GM went through six months of negotiations on Lowest Achievable Emissions Rates (LAER) with the Michigan Air Quality Division, EPA's Region V, and EPA at Research Triangle Park. According to our contacts, EPA was involved because this was a proposal for a major new plant and because it represented a test case for determining LAER in the automobile industry.

At that time LAER for the top (color) coat for passenger cars required use of water-based enamel paint, and EPA suggested it for the new van plant also. GM, however, proposed to use high-solids solvent enamel, providing data that showed it is difficult to keep the humidity inside the vans at suitable levels for working with water-based paint. GM's proposal was accepted by the regulatory authorities after some discussion. The regulatory authorities also required, as a part of LAER, the incineration, or its equivalent, of emissions from the ovens that serve the top coat. GM had not included this in its preliminary proposal. GM had used oven incinerators in the past, but they had used natural gas which GM wished to conserve. Other techniques that EPA believed could be used, such as coal-fired boilers or catalytic incinerators, GM wished to avoid because they were not in common use. The LAER negotiated was a coal-fired boiler incinerator, or its equivalent, to be installed within 32 months, the time necessary to engineer and construct it. GM, however, was able to achieve the equivalent in reductions by developing

a solvent enamel even higher in solids than required by the regulatory agencies. This was the result of a significant on-going development effort by GM and the paint manufacturers. The "equivalent" provision gave GM the incentive to develop the higher solids paint.

The permit was approved in June 1977. The new plant was working at full capacity by August 1978. It was down at the time of our interview, however, due to the lack of sales.

## III. The Internal Offsets

The GM division involved could not make all the offsets required for the new van plant. Those it made came from shutting down miscellaneous painting operations or reducing solvents.

The Environmental Activities staff at the GM Technical Center in Warren, Michigan, took the lead role in searching for offsets that could not be found within that GM division. They contacted plant engineers at other GM division plants in the area. The plant engineers are generally very knowledgeable about the operations and emissions in their plants. The Environmental Activities staff asked the plant engineers the following kinds of questions: (1) "Are there any emission reductions that could result from a cost-saving project?" (2) "Are there any emission reductions that are coming about because of product changes?" and (3) "If you have emissions reductions, are you willing to give them to another GM division?"

Some offsets came from other GM plants in the area that were downsizing their cars and thus using less paint. The main source of offsets, however, came from switching a flow-coater in another GM division. The flow-coater, which is a prime system, paints small metal parts on a belt that passes through a closed container with a line of nozzles that spray paint. The paint was formerly based on a hydrocarbon (HC) solvent which released large amounts of HC emissions upon evaporation. GM proposed to convert the solvent-based flow-coater to water-based paint. This is something the plant had had on its agenda for some time

but had not undertaken because of competing priorities for expenditures. The need to make emission offsets supplied the necessary additional incentive to make the change, hence the change was made earlier than it might have been otherwise. It is not certain, however, that the flow-coater eventually would have been converted to water-based paint, since there is some possibility that the metal parts coating line would have been closed down in a few years in favor of plastic parts which do not need to be primed.

The EPA was hesitant to approve the change to water-based paint as an offset because it believed that the expected Miscellaneous Metal Coating RACT (Reasonably Available Control Technology) guideline would require water-based paint and thus any offsets would have to be above and beyond this. However, RACT was not yet part of the Michigan State Implementation Plan (SIP) and the Clean Air Act amendments of 1977 provided that in such cases the relevant standard was that contained in the SIP. If a Miscellaneous Metal Coating RACT had been in the SIP, none of the offsets would have been allowed. As it was, however, the switch to water-based paint in the flow-coater reduced HC emissions from that process by a factor of four and resulted in a 670 ton per year emission reduction. The new system was in place by August 1, 1977.

The switch to water-based paint represented some risk to GM, but not too great, according to our contacts. There was some possibility that the system would not work and there was the likelihood of the usual learning-curve problems. At that time a similar system had been operating in a third GM division. Prior to its use in that application the water-based paint had gone through a one or two year testing period at the GM paint center, which is responsible for all new paint development and approval.

GM management's approach to technical change typically is evolutionary. Since the basic management responsibility is to get the product out, there is a tendency at the production level to avoid taking risks that might interfere with quality and production. Therefore management tries to minimize risk when they undertake technical change by phasing in

new technology slowly. They want to make sure that any new paint would maintain the quality and reliability standards of the present product. As in this case, they will usually visit and study similar installations. If it is the first of its type, they will usually undertake a limited pilot test.

Nonetheless, at the time of the switch to water-based paint in the flow-coater, water-based paint was not widely used for this type of prime application and represented the leading edge of technology. Its use is more common now in this type of application.

The firm had an economic incentive to switch to water-based paint for the flow-coater, since flow-coating with HC-based paint is very wasteful of materials. For each gallon of HC-based paint, about four gallons of thinner must be used. The use of water-based paint saves on materials. Thus, the change, which cost about $300,000, paid for itself in six months. However, other technological developments are in progress that may replace the flow-coater altogether. Electrophoretic deposition (ELPO) of metal parts is more efficient for priming and is capable of coating crevices better. Our contacts indicated that GM would tend to install ELPO, which is currently more expensive than flow-coating, if improved product quality and/or reduced materials use was warranted. A switch to plastic parts would eliminate the need for prime coating altogether, although some sort of surfacer to even out imperfections would still be necessary before applying the top coat.

To determine emissions from the process, emissions are calculated using the volume of material used in the process and subtracting the amount of material that adheres to the parts. Our contacts thought that regulatory authorities would determine compliance with the offset provision by the same means.

The switch to water-based paint required some engineering work, done by the plant, to change nozzles, lengthen the baking ovens, and make the ovens hotter.

## IV. Perceptions of Internal Offsets, LAER, and Innovation

Our contacts stated that internal offsets stimulate technological change and act to improve air quality. They felt that if internal offsets were eliminated there would be less innovation, because of LAER requirements. With respect to LAER, they believed the best way to keep new technology developing is to give incentives through LAER "equivalency" provisions, as in the case here where LAER for the oven incinerator was a coal-fired incinerator or equivalent reductions. If LAER is set too low, however, our contacts stated that it can eliminate methods still in development that could achieve the equivalent reduction. It can thus be counterproductive.

## V. Summary

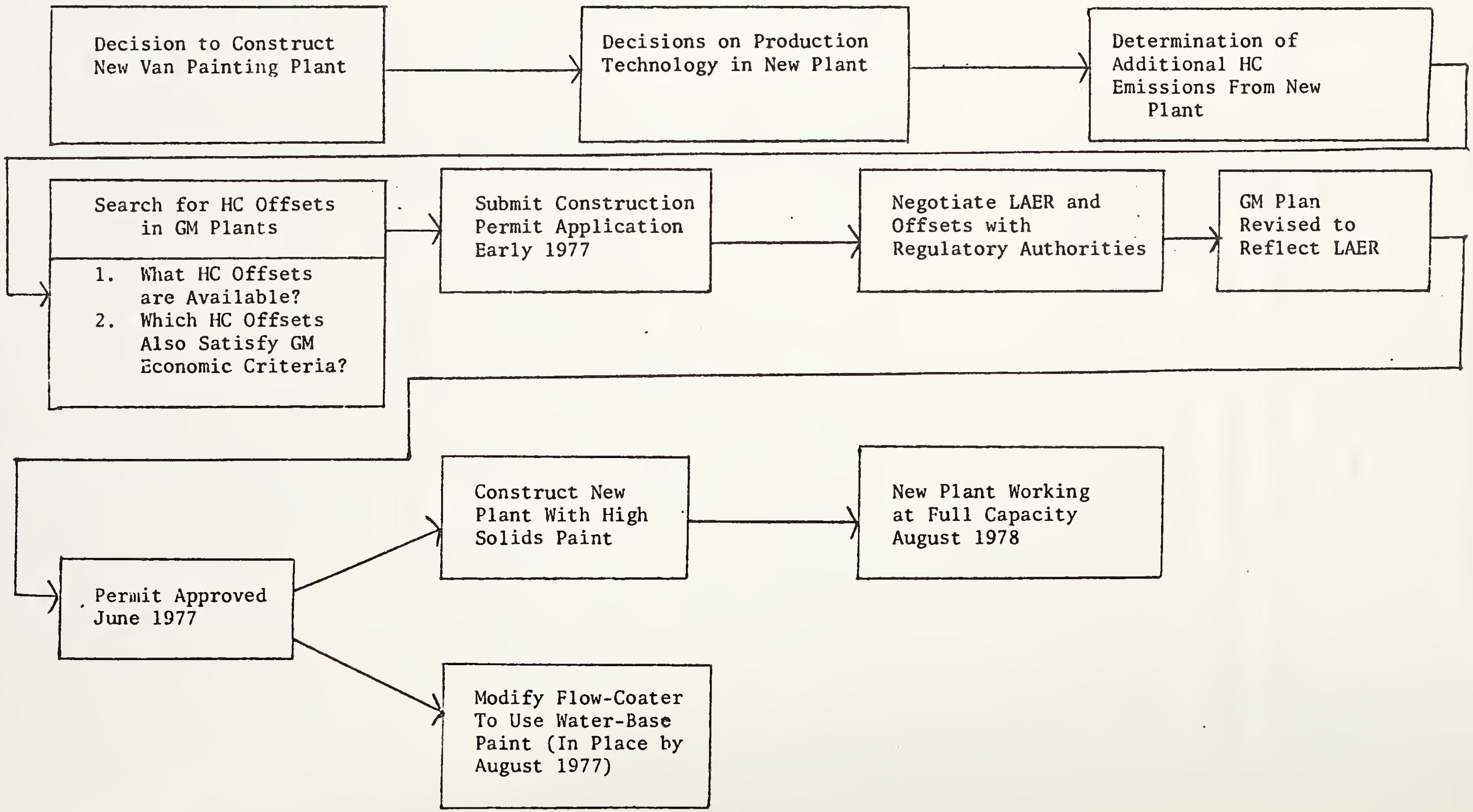
Figure 5 shows the major steps in the internal offsets process for the General Motors van painting facility. The process started with the decision to construct a new van painting facility and decisions on the nature of the production technology that would be used. Then the additional HC emissions from the new plant were determined and a search undertaken for offsets for the additional emissions. The construction permit application was submitted in early 1977. Negotiations with regulatory authorities over LAER for the new plant took about six months. After an agreement had been reached, the GM plan was revised to reflect LAER, and the permit was approved in June 1977. The modifications to make the internal offsets were in place by August 1977. The new van painting facility was in place and working at full capacity by August 1978.

In the GM case, new technology was involved in both the van painting facility for which the offsets were sought and in making the offsets themselves. In the new van painting plant, GM used a recently-developed high-solids solvent enamel to meet the "equivalent" of a LAER requirement. The new technology in making the offset involved the use of water-based paint. GM had an economic incentive to switch to water-based paint and the change paid for itself in six months. If the RACT for this operation had been in place at the time, the switch to water-based paint

would not have qualified as an offset. It seems clear, however, that the internal offsets policy caused GM to switch to water-based paint in the flow-coater sooner than it would have otherwise done. Without the policy the switch may not have occurred at all. Another interesting aspect of this case was the search among GM divisions for offsets, which utilized in-house knowledge of operations and emissions and stressed cost-savings where possible.

Figure 5

GENERAL MOTORS VAN PAINTING PLANT



# FORD MOTOR COMPANY MT. CLEMENS VINYL PLANT

## I. Background

This case involves the installation of a new vinyl printer at the Ford Motor Company Mt. Clemens Vinyl Plant and the associated internal offsets.

The Vinyl Plant is part of Ford Motor Company's Plastics, Paint and Vinyl (PPV) Division. It is located near Detroit, Michigan --an area which is attainment for sulfur dioxide ($SO_2$), total suspended particulates (primary standard only), and nitrogen dioxide ($NO_2$) and nonattainment for Ozone. There are about 25 Ford facilities in the Detroit area. The Vinyl Plant employs about 600 workers (salaried and hourly) and has capacity to produce about 28 million linear yards of automotive vinyl per year. Due to depressed automobile sales levels and to the conversion to physically smaller automobiles, the plant has been operating at levels substantially below this capacity. The Vinyl Plant makes most of the vinyl for Ford Motor Company for application in auto interiors and for vinyl roofs. Vinyl is also produced for other customers.

There are three basic processes in the Vinyl Plant: calendering, laminating, and printing. In calendering, granulated or powdered polyvinyl chloride (PVC) resin is heated, extruded in long sheets, and wound on rolls. In laminating, vinyl sheet is attached to a supporting material -- usually fabric or foam -- and assorted textures and designs are embossed on the vinyl. In the printing process, finish surface coatings are applied for decorative and protective effect.

Our contacts noted that the new printer case was unusual for a number of reasons. Funds had already been approved for the new installation when the Emission Offset Interpretative Ruling (EOIR) became effective and Ford was thus "caught in the middle" so to speak without plans, funds or time for volatile organic compound (VOC) LAER technology prior to startup of the new printer. Offsets for the new printer were used

consecutively in a sense, and, since progress on a phased construction program was underway at another location within the Division, saving of excess offset credits was allowed under the interpretative ruling.

## II. The Preconstruction Permit

The preconstruction permit involved negotiations with the Michigan Department of Natural Resources (DNR), primarily. Funds had been approved and equipment ordered for the new printer when the EOIR was issued in December 1976. At the same time, a new Ford plant within the Plastics, Paint and Vinyl Division was being constructed in Milan, Michigan. The construction at Milan was planned to proceed in incremental expansions and was, therefore, designated as a "phased construction program" by the DNR. In this situation, the EPA interpretative ruling allowed banking of emissions offsets.

Because it was proposed before the EOIR became effective, the original proposal for the new printer did not include an incinerator which, among other technologies, is considered LAER for that equipment. Ford negotiated with DNR to allow the printer to operate for six months without the incinerator while a retrofit incinerator was being designed, purchased and installed. In return, Ford agreed to more than offset the total amount of VOC emissions from the printer during the period it operated without an incinerator. Then, after the incinerator was installed on the printer, the excess offsets were applied in conjunction with the new Milan Plant.

The new printer was capable of emitting a maximum of about 530 tons per year of VOC without an incinerator. This potential was offset by two main emissions reductions: removing a painting operation elsewhere in the PPV Division (530 tons per year) and retiring an older printer at the Vinyl Plant (317 tons per year). Thus there was a large excess offset for the new printer while it operated for a half year without an incinerator. After the incinerator was installed on the new printer, its VOC emissions were about 27 tons per year. The 27 tons per year of VOC from the printer with the LAER incinerator were

permanently offset at a 1.2 to 1.0 ratio at the Mt. Clemens plant. Excess emission reductions were then used to offset new emissions at the Milan Plant at a 1.1 to 1.0 ratio.

## III. The New Source

The new printer does not represent "new" technology, according to our contacts. Essentially the same printer equipment is used widely in Ford and other vinyl plants. The new printer was installed within its own room. With the exception of one "floor sweep" exhaust fan to remove vapor which might be heavier than air, all other exhaust from the new printer room was directed through an exhaust gas incinerator. The gas fired incinerator is capable of oxidizing organic vapors at high temperatures to form carbon dioxide and water. With the recognition that higher fuel costs would be a continuing concern, it was decided to design the incinerator with primary and secondary heat recovery equipment. Thus, exhaust from the printer's drying ovens was to be preheated before entering the incinerator, and make-up combustion air for the drying ovens was also to be preheated utilizing air to air heat exchangers. For an additional initial investment, then, energy costs were minimized into the future.

## IV. General Experience With Internal Offsets

To date, internal offsets have not created a great deal of trouble for the PPV Division, according to our contacts. However, one problem exists due to the cyclic nature of the industry. Because of frequent model changes, new facilities are constantly being added and older facilities retired. Thus, much paperwork is required to document internal offsets, although the plants are not really growing.

The large number of Ford facilities in the Detroit area has made it relatively easy to get internal offsets up to the present time. The PPV Division has required large amounts of internal offsets in that area because of expansions in its plastics operations.

A method of banking offsets will make internal offsets easier to manage, according to our contacts. Michigan has informal banking; formal banking, although proposed, is not in force yet. In the absence of banking, excess emission reductions beyond the level required for offsets are "lost forever" -- that is, they cannot be applied against later expansions. This is a problem because emissions reductions often cannot be tailored precisely to the amount needed. For instance, in order to reduce emissions by 60 tons per year, it may be necessary for a firm to shut down two 50 ton per year sources, which results in 40 tons per year excess reductions. In the automobile industry, this problem is exacerbated by the cyclical nature of capital deployment and retirement.

In general, permit applications are prepared at the plant level by the plant environmental engineer. These are routed to the Division environmental engineer and then to a corporate group, the Stationary Source Environmental Control Office, for approval. Then the permits are routed back to the plant for changes or submissions. It takes an average of two months for Ford to prepare an application. The State of Michigan has 60 days to act on a permit application. There is usually some back-and-forth interaction during which the DNR requests additional information. Once at the DNR, permit approval may take two to four months.

The job of identifying offsets falls to the Division environmental engineer. He keeps records of available offsets and sends letters to plant management to keep alerted to offsets that will be needed or available in the future.

The PPV Division has one Divisional environmental engineer, who follows regulatory developments through the Federal Register, reviews permit applications, keeps track of expansion plans and availability of offsets, and handles all other environmental responsibilities. In the case of water-based paints, the Divisional environmental engineer acted to speed up the development program by pointing out that "easier" offsets would not be available for a planned 1981 expansion. He kept

track of developments in water-based paint through membership on a Division committee. He did not interact directly with paint manufacturers, however; this was done by plant-level people in the course of their normal interactions with paint manufacturers and suppliers.

Our contacts noted that regulations are becoming increasingly complex and require technically-trained people to understand and respond to them. This contributes to industry's perceived slowness to respond and perhaps, they also noted, the extreme difficulty of commenting intelligently and providing accurate compliance cost estimates on each of the myriad of proposals in the Federal Register that have potential impact on Ford Motor Company Plastics, Paint and Vinyl Division operations. Our contacts said that industrial firms are forced to make "knee-jerk" reactions as a result of EPA's 30 to 60 day comment periods, during which supporting documents often have not even been published for review.

## V. The Effect of EPA Regulations on Research and Development and Innovation

Our contacts said that EPA has sparked private research and development (R&D) toward water-based paints for coating plastics. The regulatory pressure, which affects primarily new sources, is off somewhat now, however, due to poor business conditions in the industry which have caused plans for expansion to be deferred.

Regulations require that new control technologies be evaluated -- for instance, what is LAER? According to our contacts, this burden is placed on the firm and evaluation of technologies is quite difficult. For example, they said many of the new developments described in trade journals prove, upon further examination, to require years more of development or to be unsuitable for the required application.

An individual new source permit and the required offset are by themselves unlikely to stimulate new technology because technology development may take five to ten years. New technology is not merely "produced"

in response to a need for emission offsets. It must be evolved and proven over time.

Ford Motor Company appears to be running out of "easy" offsets. It may soon have to rely on new technologies, such as water-based paint, if feasible, according to our contacts.

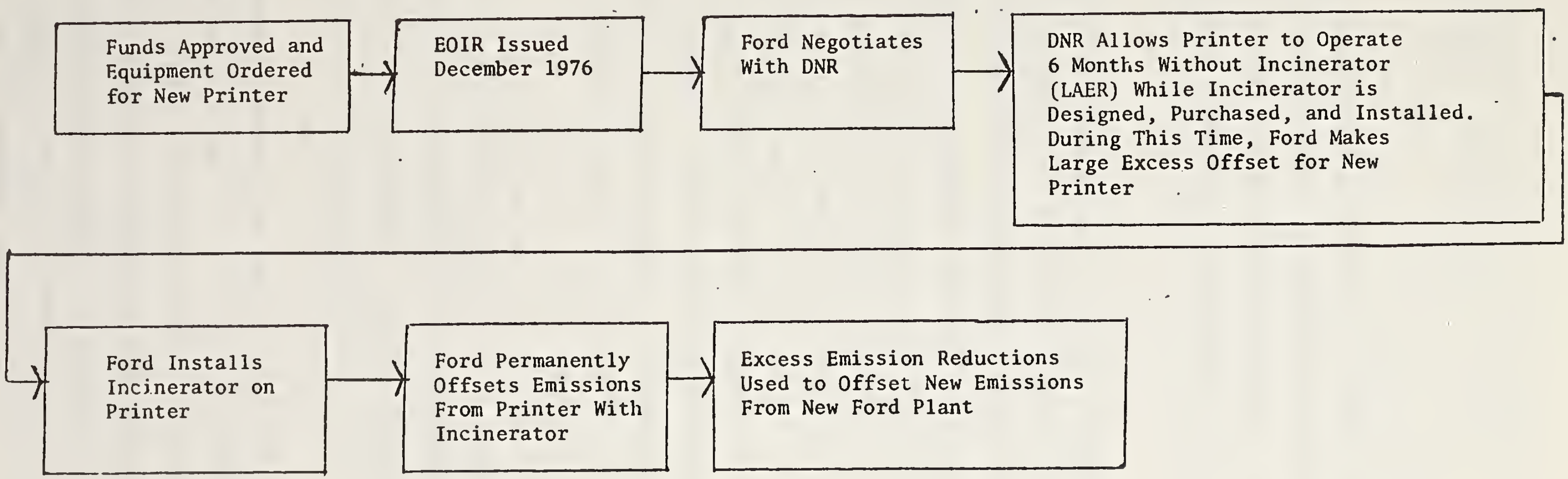
## VI. Summary

Figure 6 shows the major steps in the internal offsets process for the new printer at the Ford Motor Company Mt. Clemens Vinyl Plant. The funds had been approved and the equipment ordered for the new printer when the EOIR was issued in December 1976. Because it was proposed before the EOIR became effective, the original proposal for the new printer did not include an incinerator, which is considered LAER for that equipment. Ford negotiated with DNR to allow the printer to operate for six months without the incinerator while a retrofit incinerator was being designed, purchased, and installed. In return, Ford made a large excess offset for the new printer while it operated without an incinerator. After the incinerator had been installed, Ford permanently offset the emissions from the printer with the incinerator. Excess emission reductions were then used to offset new emissions at a new Ford plant being built in Milan, Michigan.

In the Ford case, neither the construction project (i.e., the printer) nor the offsets involved new technology. The offsets were made by retiring old units and operations. One possibly innovative aspect was the heat recovery system incorporated in the LAER-required incinerator, which was stimulated by the desire to conserve fuel. Ford contacts indicated that the prospect of needing offsets for planned expansions, coupled with exhaustion of "easy" offsets, acted to speed up new technology development in the company. This kind of effect, however, acts over the course of years, rather than months. Moreover, it depends on economic conditions that are conducive to industrial expansion and is weakened when industry is not expanding.

Figure 6

FORD MOTOR COMPANY MT. CLEMENS VINYL PLANT



## DO INTERNAL OFFSETS PROMOTE TECHNOLOGICAL INNOVATION?

A major question for ETIP and EPA is whether and how internal offsets promote technological innovation. These case studies provide some evidence, albeit preliminary and limited, pertinent to this question. Because of their preliminary and limited nature, they also raise additional questions.

For example, there are definitional questions that need more attention before a satisfying answer to the main question can be obtained. What is technological innovation? How does one define and measure it? Technologies are difficult to define. For example, low-NOx burners were described by our contacts as being in extensive use, but the very low-NOx burners purchased by the Avon refinery were believed to be the first actual installation of that particular type of low-NOx burner. Moreover, some new or improved technologies are more "innovative" than others--that is, they represent a greater degree of technical advance or emissions reductions. There are, however, no generally applicable methods for rating the "innovativeness" of a technology. Such ratings tend to be subjective and difficult to verify. Also, a technology may be new to a particular plant or company, even if it has been used elsewhere and therefore is not new to the economy. Technological innovation may also be defined as a process consisting of three major phases: invention, development, and diffusion. These are complexities that have hounded researchers on innovation for a decade and more.[9/] They cannot be put to rest in the context of a single study such as this.

Yet the question of whether and how internal offsets promote technological innovation remains. To begin to address this question in a timely fashion, it was necessary to take a somewhat practical approach to the definitional and measurement problems. It was decided to rely primarily on companies' descriptions of technologies, such as "new" or "common." Companies were also asked to describe technology in terms of the extent of its prior use, whether it had been used previously

in their own plant, and the similarity of known previous applications.

This approach has the disadvantage of obtaining subjective and possibly biased responses.[10/] It has, however, the corresponding advantage of viewing innovation as the industrial firms themselves view it. This view, and the accompanying view of the internal offsets policy as seen by the industrial firms, is important in opening a dialogue between the public and private sectors on the issue of the effects of economic incentive regulatory mechanisms on technological innovation.

Based on this way of defining innovation--i.e., technology perceived by the companies as new or little used-- it is evident that innovation did occur in some of the six cases. GM developed a new high-solids, solvent enamel for the van painting plant; the water-based flow-coater prime system it installed as an offset was not in widespread use at the time. The barge vapor flare installed by Marion as an offset was only the second such installation (the first had not been successful). The Flexicoker installed by Shell was the first such unit to be installed in the United States. The catalytic reformer with continuously-regenerated fluidized-bed catalyst installed by the Avon refinery was not in widespread use at the time and, as mentioned earlier, the very low-NOx burners on the unit were believed to be the first actual installation of that particular type.

Some of the innovations occurred in the new sources or major modifications that were being constructed, while others were installed in the existing plant to make the internal offsets. Some of the innovations were in the technology involved in the production process of the company (e.g., Shell's Flexicoker) and others were in the technology for controlling emissions from the process (e.g., Marion's barge vapor flare).

Another research question facing any study such as this is how to establish causal relationships between public policies and phenomena in the private sector. How can we be sure that the innovations that occurred in these cases were caused by the internal offsets policy, that they were not caused by something else, or did not occur by chance?

Given the nature of the case study methodology, the small number of cases studied here, and the definitional and measurement problems discussed above, the question of whether the internal offsets promoted (caused) technological innovation in these cases can only be answered in a partial and highly subjective fashion. In particular, alternative cause of innovation cannot be ruled out.

Despite the inherent epistemological problems, the six cases studied here present certain patterns that suggest to the author that the internal offsets policy did promote technological innovation, and that it did so in several ways. These patterns, which are merely sketched here, are most significant as propositions for further research.

At one level, a basic distinction may be made between two ways in which internal offsets acted to promote innovation. First, some companies installed innovative technology to make the internal offsets. That is, given the requirement to reduce emissions in the existing plant in order to be allowed to build a new plant, some firms chose to use innovative technology to reduce those emissions. The primary example of this was Marion's barge vapor flare. Second, and perhaps more important, the internal offsets policy promoted innovation in these cases by allowing the firms to build new sources or make major modifications in nonattainment areas (which would otherwise be prohibited under the Clean Air Act). In so doing, it allowed the companies to install additional plant and equipment, which often embodied innovative process and/or control technology--replacing old, inefficient equipment that had higher emissions. Examples of innovations occurring in this manner are the Shell Flexicoker and the Avon catalytic reformer.

The internal offsets policy encouraged and allowed companies to make use of their specialized knowledge of their own processes, emissions, costs, and plans for retiring equipment (knowledge that might not be available to regulatory authorities) in deciding how to make the offsets. In the GM and Ford cases, for example, the companies surveyed the plant engineers in nearby plants to identify and select offset opportunities.

In some cases, the flexibility that the internal offsets policy allows a firm in selecting what particular internal offsets to make meant that the companies were able to install controls that would pay for themselves (e.g., GM's water-based paint flow-coater) or would be less costly than alternatives (e.g., Marion's barge vapor flare.)

Internal offsets policy in the long run may exert a steadily growing incentive for companies to develop new ways of reducing emissions as the supply of potential emissions reductions declines. For instance, our Ford contacts pointed out that any given project can only draw on technology that is ready for commercial application at the time the project is proposed. Thus, they said, the short-term effect of a single permit requiring internal offsets is to stimulate the introduction or diffusion of technology that is ready for commercial application. They noted, however, that they currently have a water-based paint development program in progress as a result of regulatory pressures, including internal offsets, that they believe will necessitate a switch to water-based paint in the future.

In some cases internal offsets may stimulate innovation by offering companies an opportunity to avoid New Source Review. This appeared to be the situation in our Bay Area cases, for example. The applicable Bay Area rule, according to our contacts, specified that if a new source or major modification project increases emissions of any contaminant for which there is an ambient air quality standard by more than 250 pounds per day <u>for the plant as a whole</u> then it triggers a new source review. This rule, they said, acts as a "driving force on technological change" because it gives industry an incentive to design projects so there would be no net increases or even reductions in emissions for the plant as a whole.[11/]

This study also brings into question the wisdom and feasibility of attempting to separate internal offsets from the overall context of command and control regulations (e.g., LAER, BACT, and Reasonably Available Control Technology (RACT)) and the other emissions trading concepts (e.g., external offsets, bubble, and banking). The emissions

trading concepts, including internal offsets, are administered "on top of" command and control regulations. The new sources or modifications in these cases were generally required to install LAER or BACT, in addition to making the internal offset. In some cases internal offsets were made that would have been required later under RACT regulations, although, our contacts pointed out, in these cases emissions were reduced earlier than they would have been otherwise (i.e., GM's flow-coater). Also, in some of the cases previously banked emission reduction credits were used as internal offsets (i.e., Avon Refinery) or excess offsets were banked for future use or sale (i.e., Gulf and Shell). Since internal offsets are part of an overall air quality strategy, it may not be possible or desirable to isolate the effect of internal offsets on either technological innovation or air quality.

In this section, we have suggested some ways in which the internal offsets policy may have promoted technological innovation in the cases studied. These suggestions should not be treated as hard findings, however, because there are different opinions on the relationship between internal offsets and technological innovation. There was not agreement among the companies that we interviewed. Many companies expressed the belief that there is no connection between internal offsets and technological innovation. Some of them stated that innovation responds primarily to the business climate. Moreover, although they did not approve of the concept, some felt that innovation does respond to technology-forcing regulations such as LAER. Many did not view innovation as a goal of the internal offsets policy, but rather saw its primary goal as air quality improvement.

Our contacts who believed that innovation results from internal offsets, regarded this as a by-product of the policy. One company commented that the effects of internal offsets on technological innovation occur over time as the potential supply of internal emissions reductions declines and the firm must consider new ways of achieving internal offsets. It also noted that the long-term pressure of internal offsets policy on technological innovation is dependent on business conditions. If business conditions do not warrant expanding or making major modifications

to plant, it said, the firm has no need for internal offsets.

## Conclusion

Based on these six cases, internal offsets appear to be more innovation-encouraging than innovation-discouraging. They appear to lead to pollution reductions sooner than those reductions would occur otherwise and in an economically advantageous way for the companies involved. They allow the companies flexibility and take advantage of the companies' internal knowledge. They seem to provoke less of a confrontation mentality between industry and government.

# FOOTNOTES

* 41 FR 55524 (December 21, 1976)

** U.S. Environmental Protection Agency, Office of Planning and Management, Regulatory Reform Staff, Controlled Trading: Putting the Profit Motive to Work for Pollution Control (Washington, D. C., 1980), pp. 42, 4.

1/ 41 FR 55524 (December 21, 1976)

2/ Wes Vivien and William Hall, An Empirical Examination of U.S. Market Trading in Air Pollution Offsets (Ann Arbor, MI; University of Michigan, Institute of Public Policy Studies, 1979 (draft report)), pp. 1-1, 1-2.

3/ On December 28, 1978, the EPA announced a revised emission offset policy (44 FR 3274, January 16, 1979). The major change was to allow banking of emission offsets, according to Jack Landau, "Who Owns the Air? The Emission Offset Concept and Its Implications," Environmental Law, v. 9, 1979, p. 578.

4/ Michael H. Levin, Chief, Regulatory Reform Staff in introduction to EPA-sponsored conference, "Brokering Emissions Reduction Credits," January 26, 1981, Washington Hilton, Washington, D. C.

5/ This interpretation is consistent with that in Richard A. Liroff, Air Pollution Offsets: Trading, Selling, and Banking (Washington, D. C., The Conservation Foundation, 1980) which provides additional background on the historical development of, and issues involved in, the offset policy.

6/ U.S. Environmental Protection Agency, Office of Planning and Management, Regulatory Reform Staff, Controlled Trading: Putting the Profit Motive to Work for Pollution Control (Washington, D. C., 1980), pp. 42, 4.

7/ Vivien and Hall, Market Trading in Air Pollution Offsets, Chapter 7.

8/ Much of the material on the expansion program is drawn from "Port Arthur Refinery Announces Phase II," Downstream, September/October 1980. (Published by GORAM, Houston, TX.)

9/ See, for example, the discussions of these problems in the following: Universities--National Bureau Committee for Economic Research, The Rate and Direction of Inventive Activity (Princeton: Princeton University Press, 1962); U.S. National Science Foundation, Research and Development and Economic Growth/Productivity (Washington, D.C., U.S. Government Printing Office, 1972); and U.S. National Science Foundation, Office of National R&D Assessment, Technological Innovation and Federal Government Policy (Washington, D.C., 1976).

10/ We tried to reduce this possible source of error by stressing to our contacts that we ourselves were not looking for especially innovative technology. In several instances our contacts told us that the technology being discussed was "nothing new" or "quite common," etc.

11/ This finding may be especially significant in light of changes in EPA's definition of source issued October 14, 1981--i.e., the "netting" provision. (46 FR 50766). Under this provision the definition of source in nonattainment areas was broadened to be an entire plant rather than an individual piece of process equipment within the plant. EPA noted that this had the practical effect of reducing the coverage of new source review (NSR) in nonattainment areas. It also noted that one of its reasons for making the change was to remove a barrier to modernization of the nation's industrial base. In effect, it appears to this author that firms wishing to add a piece of new process equipment to an existing plant in nonattainment areas may now make what amount to informal "internal offsets" and by keeping the emissions of the overall plant below the trigger level avoid new source review.

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☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

11. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)

This report describes the experiences of six industrial firms with the new Federal policy of internal offsets. Offsets are part of a group of regulatory reforms initiated by the Environmental Protection Agency and called by the generic title of "emissions trading." Offsets were introduced to allow continued economic growth in nonattainment areas and to stimulate innovation in pollution control and process technology by making it profitable for firms to create more reductions than the law now requires. The report discusses the problems of defining and measuring innovation as well as presenting industrial firm perceptions of innovation associated with offset cases.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)

Offsets, emissions trading, air pollution, ETIP, administrative experiment, innovation.

13. AVAILABILITY

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